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PROPELLANT SURVEILLANCE REPORT ANB-3066 PROPELLANT.(U)
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UNITED STATES AIR FORCE
HILL AIR FORCE BASE, UTAH 84056

PROPELLANT SURVEILLANCE REPORT ANB-3066 PROPELLANT

PROPELLANT LABORATORY SECTION

MAKPH REPORT NR 450(80)

DECEMBER 1980

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

MAKPH REPORT NR 450(80)
MMWRM PROJECT M14058C

PROPELLANT SURVEILLANCE REPORT
ANB-3066 PROPELLANT

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December 1980

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ABSTRACT

This report contains test results from LGM-30 F and G, Stage II and Stage III propellant. Data are shown in linear regression plots.

The differences between polymers used in the propellant are shown in the composite plots for very low rate tensile, high rate tensile and stress relaxation data and are most evident in gradient stress relaxation modulus.

Case liner bonds continue to show significant degradation although the rate of change has slowed.

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REFERENCES

Report Nr	Title	Date
MAGCP 75 (67)	Zero Time Test Results LGM-30 Second Stage Wing VI Propellant	13 Jan 67
MAGCP 111 (67)	ATP Test Results LGM-30 Stage II Propellant Wing VI, Phase I	1 Dec 67
MAGCP 142 (68)	ATP Test Results LGM-30, Stage II Propellant, Wing VI, Phase I Series II	Nov 68
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MAGCP 212 (71)	Propellant Surveillance Report LGM-30 Stage II (Wing 6 ANB-3066)	Jun 71
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MVS-1	Manufacturing Variables, Study of The Minuteman Stage II Motor	11 Jun 76
0162-06-SAAS-18	Ten Year Aging and Storage Program Wing VI Minuteman Second Stage	18 Aug 77
0162-06-SAAS-19	Motors and Components Program Progress	19 Feb 78
0162-06-SAAS-20		20 May 78

GLOSSARY OF ABBREVIATIONS AND TERMS

Aging Trend	A change in properties of performance resulting from aging of material or component
ANA	Aerojet Propellant, Stage III (ANB 3066 Formulation)
ANT	Thiokol Propellant, Stage III (ANB 3066 Formulation)
ANB	Aerojet Propellant, Stage II (ANB 3066 Formulation)
ASPC	Aerojet Strategic Propulsion Co.
CSA	Cross Sectional Area
DB	Dogbone
Degradation	Gradual deterioration of properties or performance
E	Modulus (psi), defined as the slope of the line drawn tangent to the initial linear portion of the curve
EB	End Bonded
EGL	Effective Gage Length
e_m	Strain at Maximum Stress (in/in)
e_r	Strain at Rupture (in/in)
"F" ratio	The ratio of the variance accounted for by the regression function to the random unexplained variance. The regression function having the most significant "F" ratio is used for plotting data. The ratio is also used in detecting significant changes in random variation between succeeding time points.
JANNAF	Joint Army, Navy, NASA, Air Force Committee
MAKPH	Propellant Laboratory at OOALC
OOALC	Ogden Air Logistics Center
Post Curing	Period up to 12 - 16 months after manufacture

GLOSSARY OF ABBREVIATIONS AND TERMS (CONT.)

Regression	The general form of the regression equation is $Y = a + bx$
Regression Line	Line representing mean test values with respect to time
S_b	Standard error of estimate of the regression coefficient
S_e or $S_{Y.X}$	Standard deviation of the data about the regression line
S_m	Maximum Stress (psi)
S_r	Stress at Rupture (psi)
Standard Deviation (S_y)	Square root of variance
Strain Rate	Crosshead speed divided by the EGL
Thiokol	Thiokol/Wasatch Division
"t" Test	A statistical test used to detect significant differences between a measured parameter and an expected value of the parameter (determines if regression slope differs from zero at the 95% confidence level)
Variance	The sum of squares of deviations of the test results from the mean of the series after division by one less than the total number of test results
3 Sigma Band	The area between the upper and lower 3 sigma limit. It can be expected that 99.73% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.
90-90 Band	It can be stated with 90% confidence that 90% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.

SECTION I

INTRODUCTION

A. PURPOSE:

The purpose of testing ANB-3066 propellant, used in Minuteman II Stage II and Minuteman III Stage II and Stage III, is to monitor and evaluate aging effects on this propellant which will contribute to the operational motor serviceability prediction. Testing was performed according to General Test Directive GTD-2C, Amendment 1, and MMWRBM Project M14058C.

B. BACKGROUND:

Service life testing of ANB-3066 carton propellant from Aerojet production began at Ogden ALC in 1966. When production for Minuteman III Stage III was transferred to Thiokol, the propellant samples from both Aerojet and Thiokol were tested. As lined cartons were produced, these were tested adding propellant liner bond specimens to the program. This report contains data from all these sources for propellant aged 13 to 162 months.

Although many of the parameters tested indicate significant aging trends, only case liner/insulation bond strengths appear to be approaching the alert limit. Significance tables for aging trend lines are given in the respective sections of the report.

Statistical techniques used are described in Section III.

Low rate uniaxial tensile tests and hardness are routine tests for all propellant. The next report will include these data. Poisson's ratio and cohesive tear energy tests have been applied to only a portion of the cartons. Regressions are shown only when all parameters of a test are significant.

SECTION II

TEST PROGRAM

Cartons representing raw material combinations were subjected to a random selection process designed to test all material lots within a two year-four test periods interval. When propellant cartons have been aged one year. they are added to the test program. Latest acquisition of Stage II was manufactured Dec 17, 1978, and Stage III manufactured April 4, 1977.

Propellant cartons are identified by source of manufacture. Stage II and III propellant manufactured by Aerojet Strategic Propulsion Company is identified as ANB and ANA respectively. Thiokol Company Stage III propellant is identified as ANT. All regressions use this nomenclature as well as additional information as to the type of carton, lined or unlined. Symbols are used on multiple regressions to separate types. There were two suppliers for polymers for Stage II propellant, "G" polymer manufactured by General Tire and Rubber and "P" polymer for Phillips. In this report the two polymer types have been treated statistically.

Lined and unlined cartons of ANB and ANT have been combined in regression analysis for comparison purposes and cover the time span from 13 through 162 mo.

The physical-mechanical tests which relate directly to stress analysis are limited. Very low rate tensile test data is related to storage conditions, and high rate rails tested under pressure relate to ignition. Stress relaxation modulus also relates to storage conditions. The thermal coefficient of linear expansion reflects some of the thermal stress to which the motor is exposed.

Low rate uniaxial tensile tests and hardness are routine tests for all propellant. These data were subjected to statistical analyses in the last report. Poisson's ratio and cohesive tear energy tests have been applied to only a portion of the cartons. Data from these tests has been analyzed for this report.

TABLE 2-1

Comparison of Standard Deviation

System	Very Low Rate Tensile			High Rate Tensile			Stress Relaxation			
							1%		3%	
	Sm	er	E	Sm	er	E	10 sec	1000 sec	10 sec	1000 sec
ANA G Unlined	6.16	.0172	70.48	32.19	.0235	834.15				
ANB G Unlined	7.82	.0193	96.00	36.56	.0300	1304.66	174.54	110.21	160.56	85.84
ANB G Lined	6.93	.0187	83.05	28.42	.0219	687.09	91.97	52.06	87.52	52.74
ANB P Unlined	8.56	.0320	134.51	40.37	.0306	1298.00	253.56	147.03	227.47	130.72
ANB P Lined	7.24	.0187	83.20	36.67	.0267	675.97	109.31	67.58	113.81	67.18
ANT P Unlined	8.79	.0210	99.88	33.08	.0285	805.10	142.69	102.38	169.01	100.09
ANT P Lined	8.14	.0172	73.53	33.28	.0223	698.38	122.16	76.49	118.38	68.04
ANA & ANG G Unlined	7.57	.0190	91.71	36.17	.0304	1239.89	174.43	110.17		
ANB G & P Unlined	8.28	.0262	116.85	43.31	.0317	1320.32	240.19	140.06		
ANB G & P lined	7.14	.0189	83.79	34.55	.0254	677.16	104.70	61.86		
ANB & ANT P Unlined	9.00	.0301	127.57	37.65	.0338	1162.80	222. 9	129.48		
ANB & ANT P Lined	8.26	.0195	85.08	35.78	.0264	773.75	121.98	76.06		

SECTION III
STATISTICAL SUMMARY

Data analyses of all propellant tested by MAKPH having the ANB 3066 formulation are contained in this report. ANB 3066 propellant is divided into three groups, each group pertaining to a specific rocket motor application. These propellant groups are further classified with regards to the manufacturer of the polymer contained in the propellant. The two manufacturers of ANB 3066 polymer are General Tire and Rubber ('G' type) and Phillips ('P' type). The three propellant groups are designated in this report as follows:

Code	Polymer Type	Manufacturer and System Application
ANA	G	Aerojet: MINUTEMAN III, Stage III
ANB	G and P	Aerojet: MINUTEMAN II, Stage II
ANT	P	Thiokol: MINUTEMAN III, Stage III

Propellant specimens for the ANA group were taken from unlined cartons and contains only "G" type polymer. Specimens for the ANB and ANT groups were taken from unlined cartons and also from cartons having a simulated case liner along one surface of the carton. Propellant from the ANB group contains both "G" and "P" type polymers. ANT propellant contains only "P" type polymer. Each propellant group is further sub-divided into propellant lots.

Test data from each propellant group have previously been analyzed to test for similarities between propellant lots within a given propellant group, as well as polymer type and carton type. The results of these analyses indicated statistically significant differences in the test data which preclude combining

data from different groups, lots, or cartons. These analyses are shown in Tables 3 - 1 through 3 - 6.

The statistical approach used for this report was to characterize the aging trend for each test parameter using linear regression analyses. Regression techniques were used to study a particular test response as a function of propellant age. A simple linear regression model of the form, $Y = a + b(X)$, was used by assigning propellant age to the variable X in the model.

Separate regression analyses were performed for each propellant group and sub group; i.e., for a specific carton type within a given polymer and propellant group. Regression plots have been included where the slope of the regression line is significantly different from a line of zero slope for all parameters. Tables providing a summary of the significance or non-significance of the regression analysis for each test parameter are included in an appropriate section of this report for each test conducted. Table 2-1 provides a summary standard deviations for the three tests of greatest importance.

Several regression analyses were performed on combined data for various carton types and propellant groups. Carton types and propellant groups are differentiated on the plots for these analyses by using different plotting symbols. Regression plots of these combined or "composite" data are included in this report solely for comparison with corresponding plots from the last test period.

TABLE 3-1

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSIONS

VERY LOW RATE TENSILE (0.0002 in/min)

		Sm	Er	E
ANA-ANB (G-Polymer, Unlined)				
	Residual Variance	S	S	S
	Slope	NS	NS	NS
	Elevation	S	S	NS
Lined-Unlined (ANB P-Polymer)				
	Residual Variance	S	S	S
	Slope	S	S	S
	Elevation	S	NS	S
Lined-Unlined (ANT P-Polymer)				
	Residual Variance	NS	S	S
	Slope	S	S	NS
	Elevation	S	S	S
G-P Polymer (ANB Lined)				
	Residual Variance	NS	NS	NS
	Slope	NS	NS	NS
	Elevation	NS	S	NS
G-P Polymer (ANB Unlined)				
	Residual Variance	S	S	S
	Slope	NS	NS	NS
	Elevation	S	NS	S
ANA-ANB-ANT - Lined-Unlined - G-P				
	Chi-square Variance	S	S	S
	Slope	S	S	S
	Elevation	S	S	S

NOTE: Sm = Maximum Stress (psi)
Er = Strain at Rupture (in/in)
E = Modulus (psi)

See pages x and xi for additional information on terms and abbreviations.

TABLE 3-2

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSIONS

HIGH RATE TRIAXIAL TENSILE (1750 in/min, 600 psi)

		Sm	Er	E
ANA (G Unlined) - ANT (P Unlined)				
	Residual Variance	S	S	S
	Slope	S	S	S
	Elevation	S	S	S
G-P Polymers (ANB Unlined)				
	Residual Variance	S	NS	NS
	Slope	NS	S	NS
	Elevation	S	S	S
G-P Polymers (ANB Lined)				
	Residual Variance	S	S	NS
	Slope	NS	S	S
	Elevation	NS	NS	NS
Lined - Unlined (ANB P-polymer)				
	Residual Variance	NS	NS	S
	Slope	NS	NS	S
	Elevation	S	S	S
Lined - Unlined (ANT P-polymer)				
	Residual Variance	NS	S	S
	Slope	NS	S	S
	Elevation	S	S	NS
ANA - ANB (G Unlined)				
	Residual Variance	NS	S	S
	Slope	NS	NS	NS
	Elevation	S	S	S

TABLE 3-3

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSIONS

HIGH RATE HYDROSTATIC TENSILE (1750 in/min, 600 psi)

		Sm	Er	E
G - P (ANB Unlined)				
	Residual Variance	S	S	S
	Slope	NS	S	S
	Elevation	S	S	S
G - P (ANB Lined)				
	Residual Variance	NS	S*	S
	Slope	S	NS	S
	Elevation	S	NS	S
Lined-Unlined (ANT P-polymer)				
	Residual Variance	NS	S	NS
	Slope	NS	NS	NS
	Elevation	S	NS	S
ANB(G) - ANB (P) -ANT (P) (Lined)				
	Residual Variance	NS	NS	S
	Slope	S	NS	S
	Elevation	S	NS	S

*Close to being significant

TABLE 3-4

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSION

STRESS RELAXATION MODULUS

	1% Strain		3% Strain	
	10 sec	100 sec	10 sec	100 sec
G - P (ANB Unlined)				
Residual Variance	S	S	S	S
Slope	S	S	S	S
Elevation	S	S	S	S
G - P (ANB Lined)				
Residual Variance	NS	S*	S	S*
Slope	NS	NS	NS	NS
Elevation	S	NS	S	NS
Lined - Unlined (ANT P-polymer)				
Residual Variance	S	S	S	S
Slope	S	S	S	S
Elevation	NS	NS	S	S
Lined - Unlined (ANB P-polymer)				
Residual Variance	S	S	S	S
Slope	NS	NS	NS	NS
Elevation	S	S	S	S
Lined - Unlined (ANB G)				
Residual Variance	S	S	S	S
Slope	NS	NS	NS	S
Elevation	S	S	S	S
ANA - ANB (G Unlined)				
Residual Variance	NS	NS	NS	NS
Slope	NS	NS	S	S
Elevation	NS	S	NS	NS

* Close to being not significant

TABLE 3-5

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSION

	TCLE Glass Point	TCLE Below GP	TCLE Above GP
G - P (ANB Unlined)			
Residual Variance	S	NS	S*
Slope	NS	NS	NS
Elevation	NS	S	NS
G - P (ANB Lined)			
Residual Variance	S	NS	S
Slope	NS	NS	NS
Elevation	S	NS	S
Lined - Unlined (ANT P-polymer)			
Residual Variance	S	S	S
Slope	S	S	NS
Elevation	S	S	NS
Lined - Unlined (ANB P-polymer)			
Residual variance	NS	NS	S
Slope	NS	NS	S
Elevation	S	S	S
Lined - Unlined (ANB G-polymer)			
Residual Variance	S	NS	S
Slope	NS	S	NS
Elevation	S	S	S
ANA - ANB (G - Polymer Unlined)			
Residual Variance	S	S	S
Slope	NS	NS	NS
Elevation	NS	S	S

* Close to being not significant

TABLE 3-6

ANALYSIS OF COVARIANCE COMPARISON OF REGRESSION

STRAIN DILATATION

		Dilatation at Max Strain	Poisson's Ratio
G - P (ANB Unlined)			
	Residual Variance	S	S
	Slope	NS	NS
	Elevation	S	S
G - P (ANB Lined)			
	Residual Variance	S	S
	Slope	NS	NS
	Elevation	NS	NS
Lined - Unlined (ANT P-polymer)			
	Residual Variance	S	S
	Slope	NS	NS
	Elevation	NS	NS
Lined - Unlined (ANB P-polymer)			
	Residual Variance	S	S
	Slope	S	NS
	Elevation	NS	NS
Lined - Unlined (ANB G - Polymer)			
	Residual Variance	S	S
	Slope	S	NS
	Elevation	NS	NS
ANA - ANB (G - Polymer Unlined)			
	Residual Variance	NS	NS
	Slope	NS	NS
	Elevation	S	S

SECTION IV

VERY LOW RATE TENSILE

This test uses a 1/2 inch thick (1.27 cm) JANNAF dogbone. The specimens are tested at a crosshead speed of 2 x 10^{-4} in/min (8.5 x 10^{-2} cm/sec) 7-°F (25 °C) and ambient RH. Very low rate tensile testing is related to strain capability for storage at 60°F.

Lined cartons show a statistically significant decrease in strain at rupture except for ANB "P". Maximum stress is generally statistically increased (exception ANT "P") modulus is also significantly increased.

Unlined cartons show a statistical increase in strain at rupture, and an increase in maximum stress. In general, modulus shows a significant decrease (ANT "P" being the exception).

Lined cartons show lower standard deviations than unlined cartons.

TABLE 4-1
VERY LOW RATE TENSILE

Significance of Regression Slopes

SYSTEM	Sm	Fig	er	Fig	E	Fig
ANA G Unlined	Sig inc	4-1	Sig inc	4-2	Sig dec	4-3
ANB G Unlined	Sig inc	4-4	Sig inc	4-5	Sig dec	4-6
ANB G Lined	Sig inc	4-7	Sig dec	4-8	Sig inc	4-9
ANB P Unlined	NS		Sig inc		Sig dec	
ANB P Lined	Sig inc		NS		Sig inc	
ANT P Unlined	Sig inc	4-10	Sig inc	4-11	Sig inc	4-12
ANT P Lined	NS		Sig dec		Sig inc	
ANA & ANB G Unlined	Sig inc	4-13	Sig inc	4-14	Sig dec	4-15
ANB G & P Unlined	Sig inc	4-16	Sig inc	4-17	Sig dec	4-18
ANB G & P Lined	Sig inc	4-19	Sig dec	4-20	Sig inc	4-21
ANB & ANT P Unlined	Sig inc		Sig inc		NS	
ANB & ANT P Lined	Sig inc	4-22	Sig dec	4-23	Sig inc	4-24

NS = Not significantly different from zero slope
Sig Inc = Positive slope
Sig Dec = Negative slope

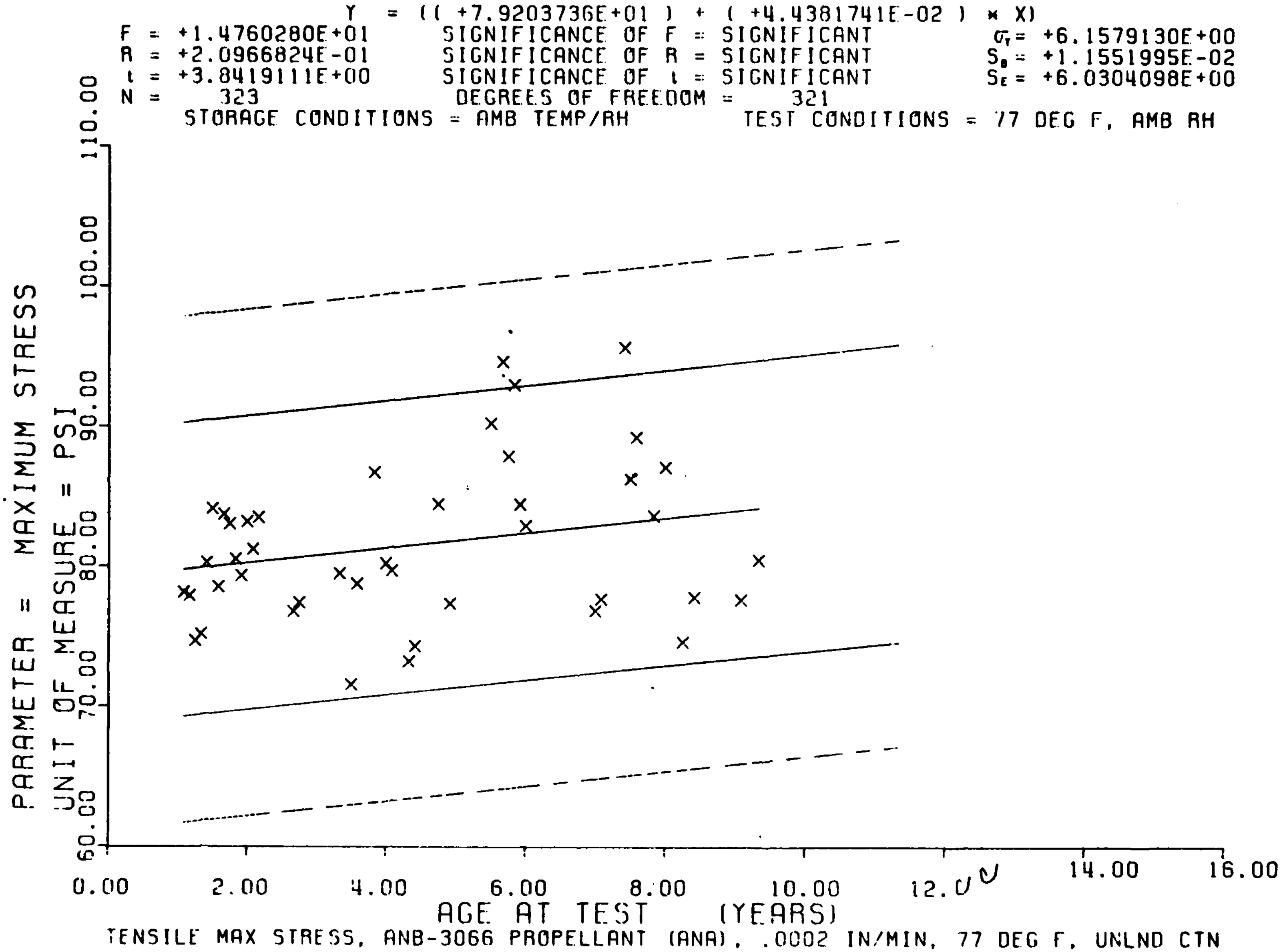
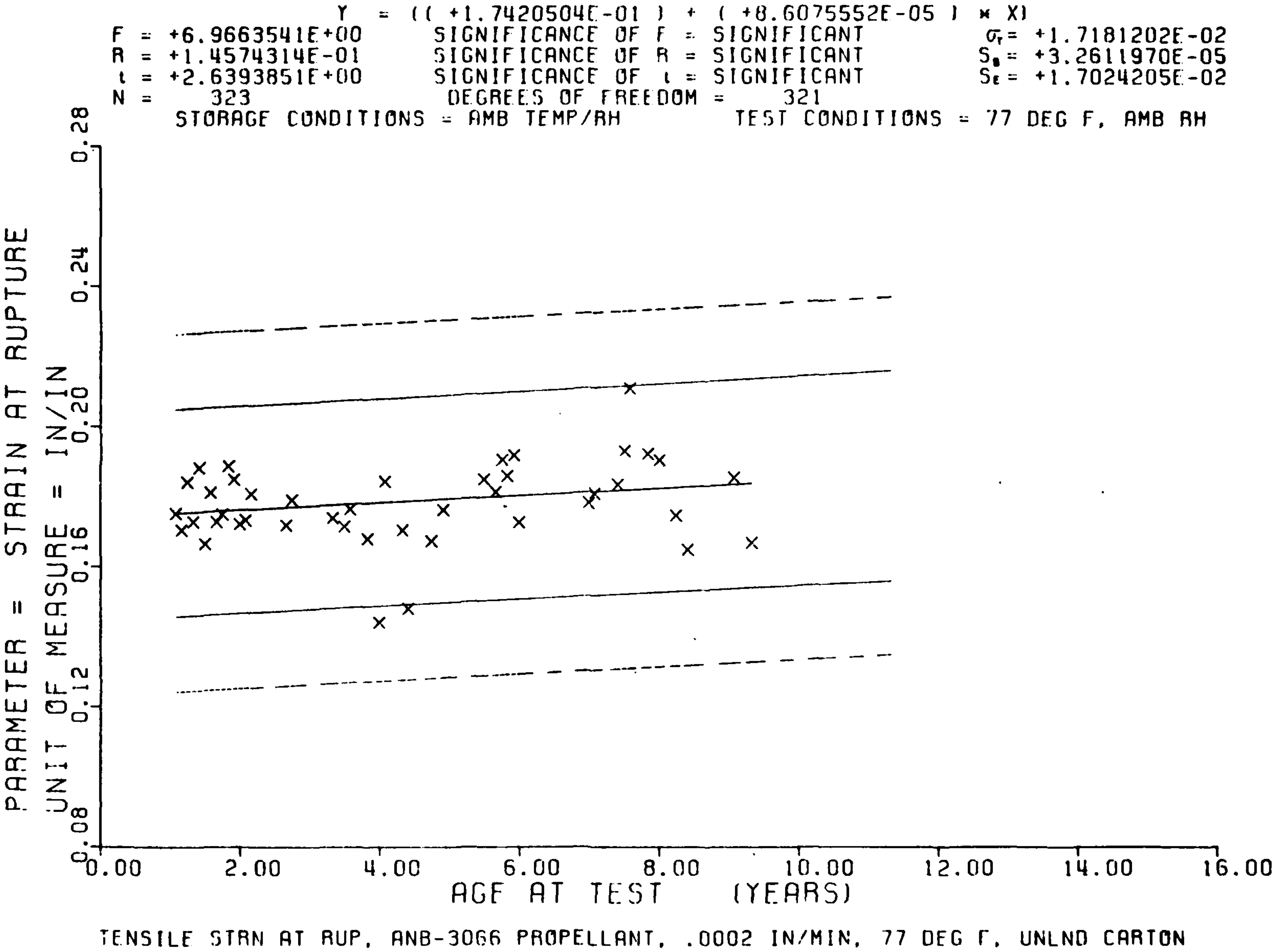

Y = ((+7.9203736E+01) + (+4.4381741E-02) * X)
F = +1.4760280E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +6.1579130E+00
R = +2.0966824E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.1551995E-02
t = +3.8419111E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +6.0304098E+00
N = 323 DEGREES OF FREEDOM = 321
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
110.00
100.00
90.00
80.00
70.00
60.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE MAX STRESS, ANB-3066 PROPELLANT (ANA), .0002 IN/MIN, 77 DEG F, UNLND CTN

Figure 4-1



Y = ((+1.7420504E-01) + (+8.6075552E-05) * X)
F = +6.9663541E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.7181202E-02
R = +1.4574314E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.2611970E-05
t = +2.6393851E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.7024205E-02
N = 323 DEGREES OF FREEDOM = 321
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.08
0.12
0.16
0.20
0.24
0.28
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE STRN AT RUP, ANB-3066 PROPELLANT, .0002 IN/MIN, 77 DEG F, UNLND CARTON

Figure 4-2

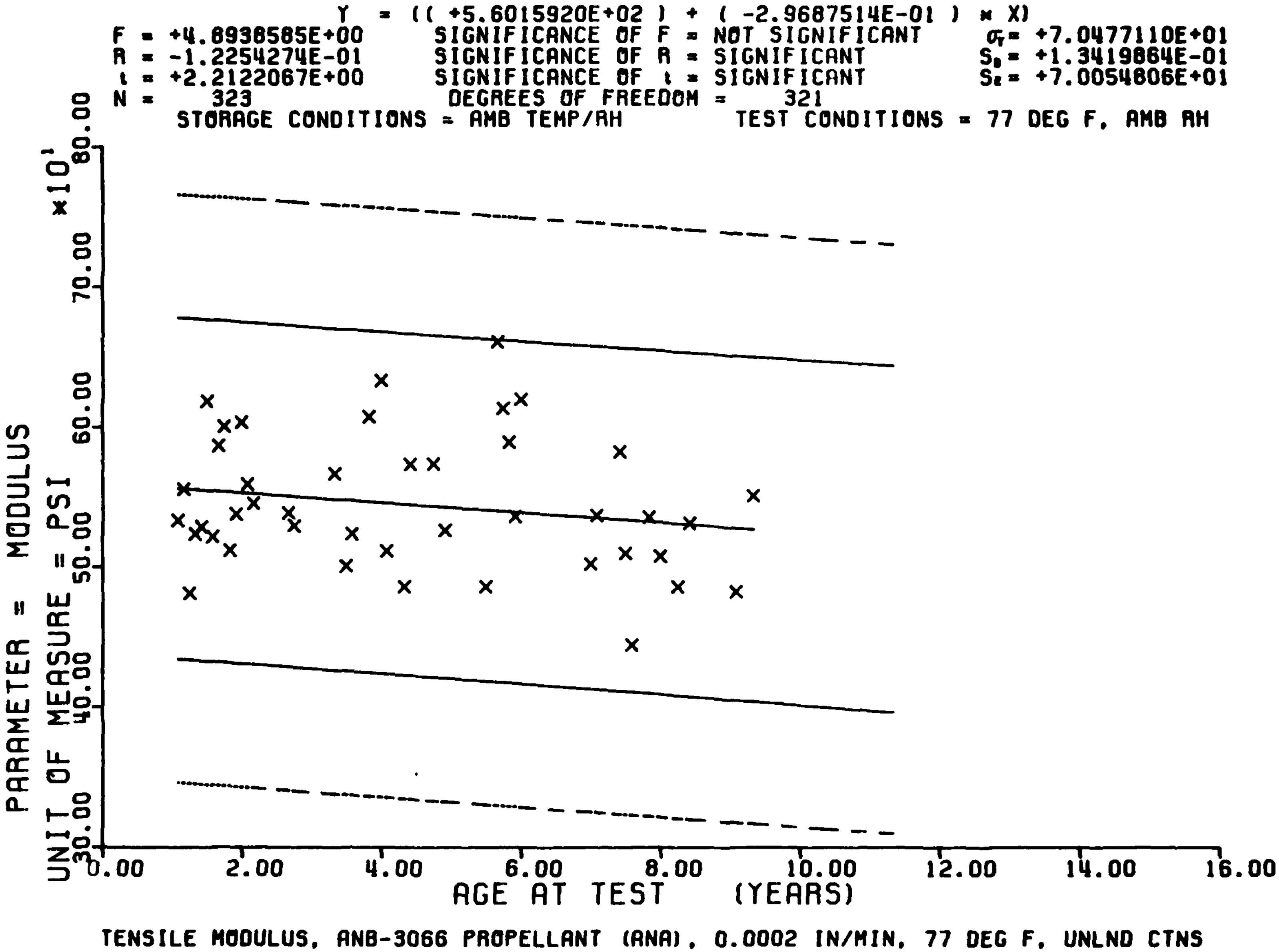

Y = ((+5.6015920E+02) + (-2.9687514E-01) * X)
F = +4.8938585E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σT= +7.0477110E+01
R = -1.2254274E-01 SIGNIFICANCE OF R = SIGNIFICANT S0= +1.3419864E-01
t = +2.2122067E+00 SIGNIFICANCE OF t = SIGNIFICANT S1= +7.0054806E+01
N = 323 DEGREES OF FREEDOM = 321
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = MODULUS
UNIT OF MEASURE = PSI
×10¹
80.00
70.00
60.00
50.00
40.00
30.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE MODULUS, ANB-3066 PROPELLANT (ANA), 0.0002 IN/MIN, 77 DEG F, UNLND CTNS

Figure 4-3

Y = ((+7.8012291E+01) + (+1.6423942E-02) × X)

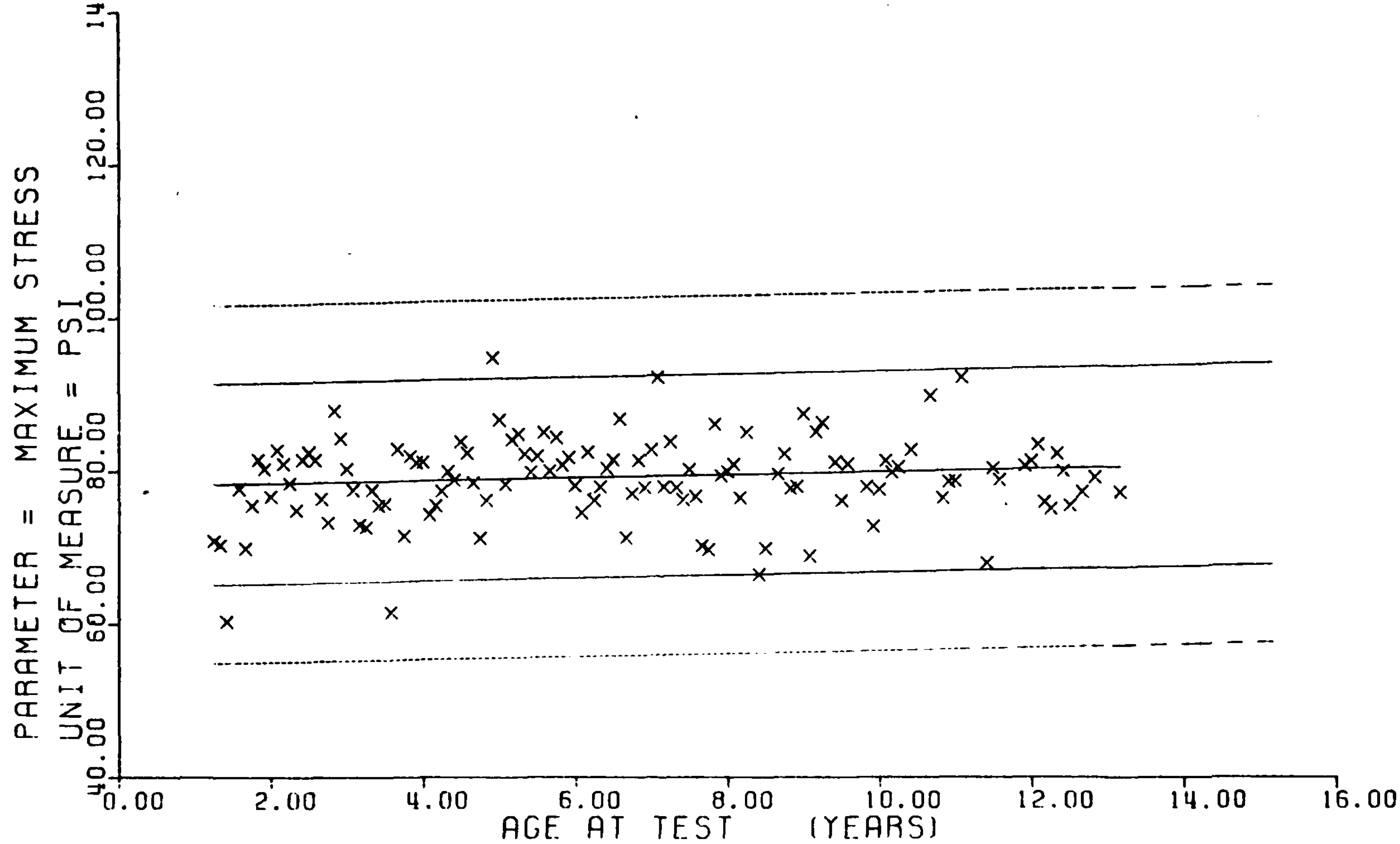
F = +6.6169156E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +7.8183871E+00

R = +6.7191999E-02 SIGNIFICANCE OF R = SIGNIFICANT S_B = +6.3848342E-03

t = +2.5723366E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +7.8033909E+00

N = 1461 DEGREES OF FREEDOM = 1459

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE MAX STRESS, ANB.3066 PROPELLANT (ANB. G), .0002 IN/MIN, 77 D UNLND CTN

Figure 4-4

Y = ((+1.6579328E-01) + (+1.7708146E-04) * X)

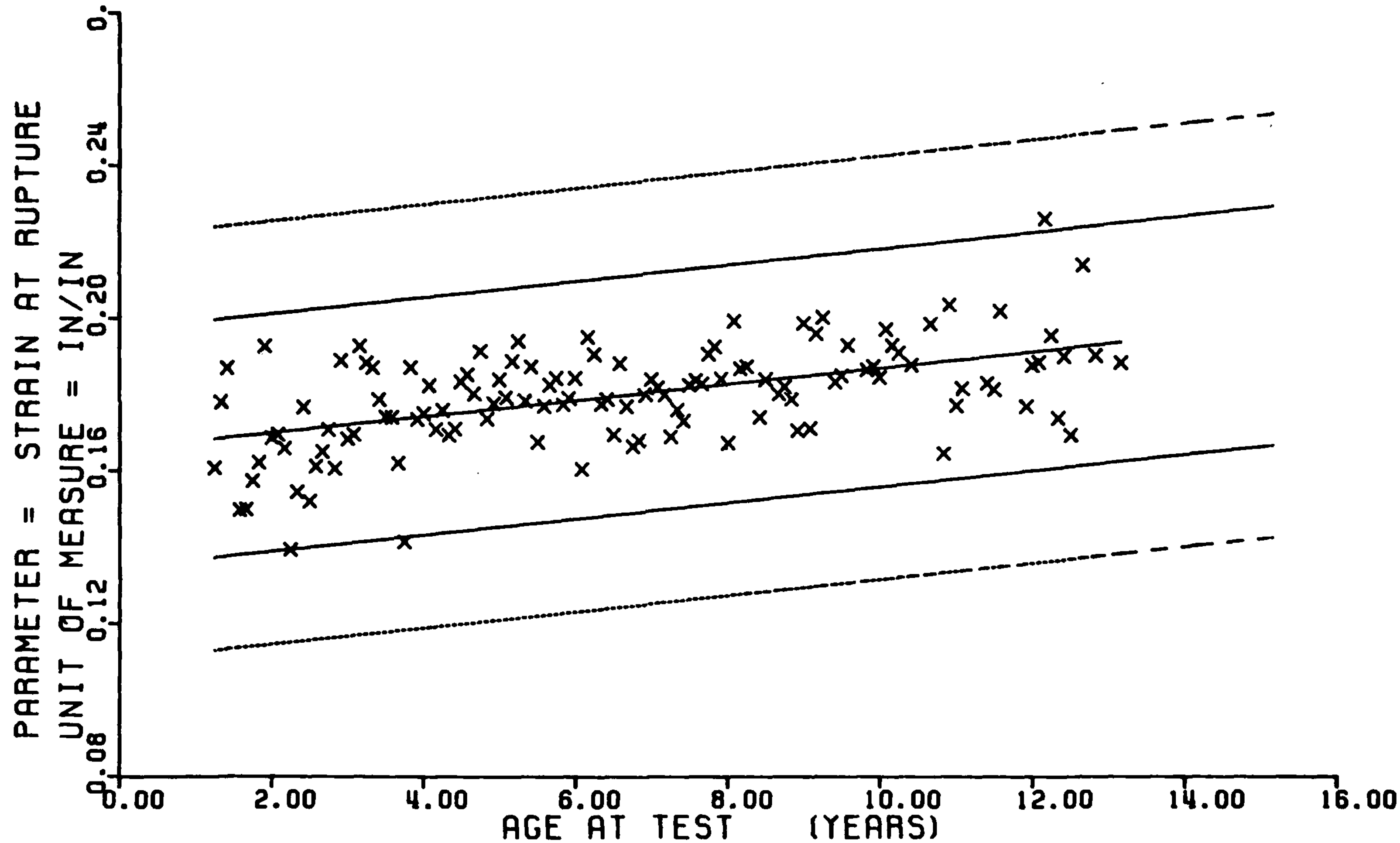
F = +1.3702638E+02   SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.9330733E-02

R = +2.9300975E-01   SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.5127633E-05

t = +1.1705827E+01   SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.8488630E-02

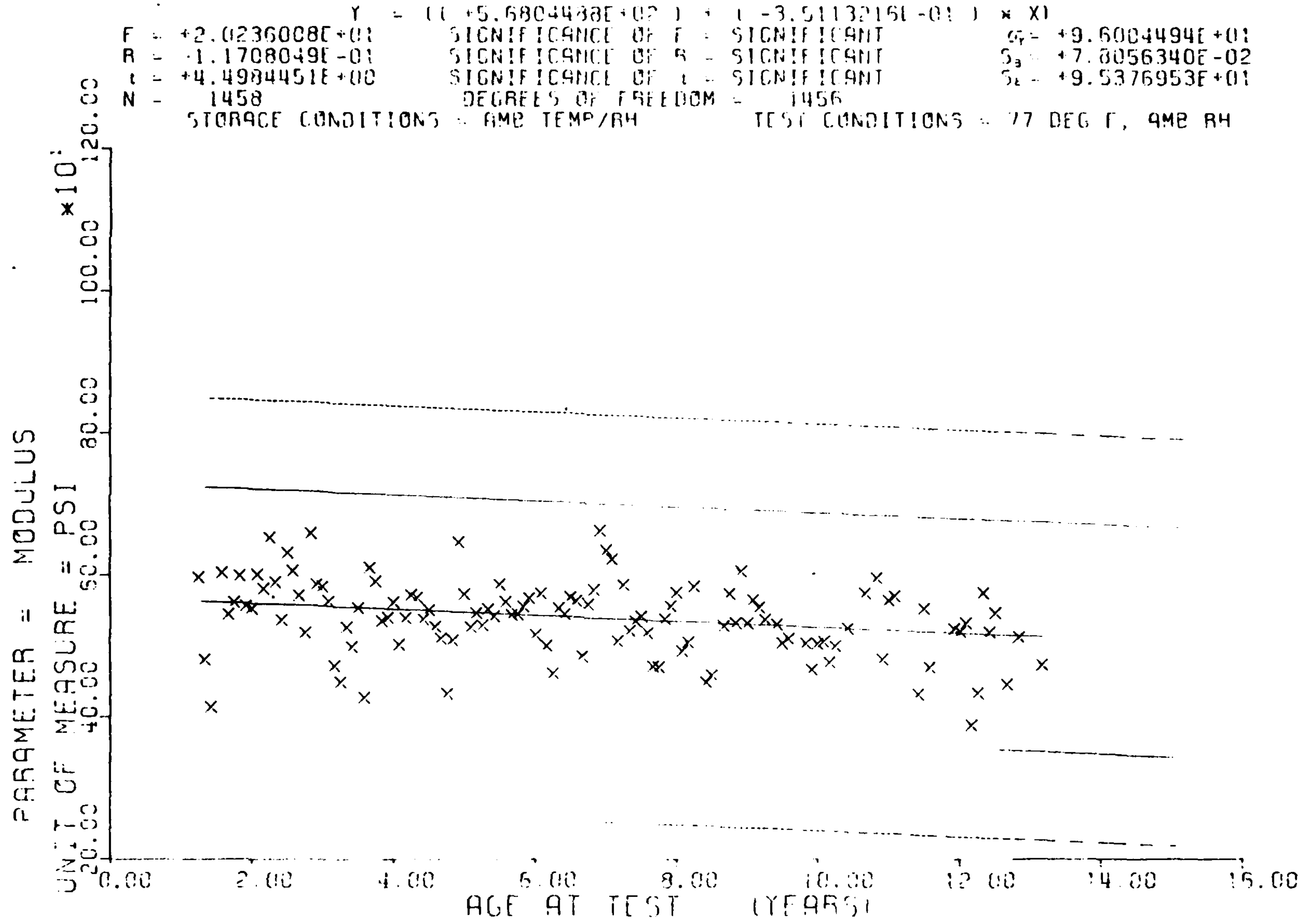
N = 1461   DEGREES OF FREEDOM = 1459

STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = 77 DEG F, AMB RH



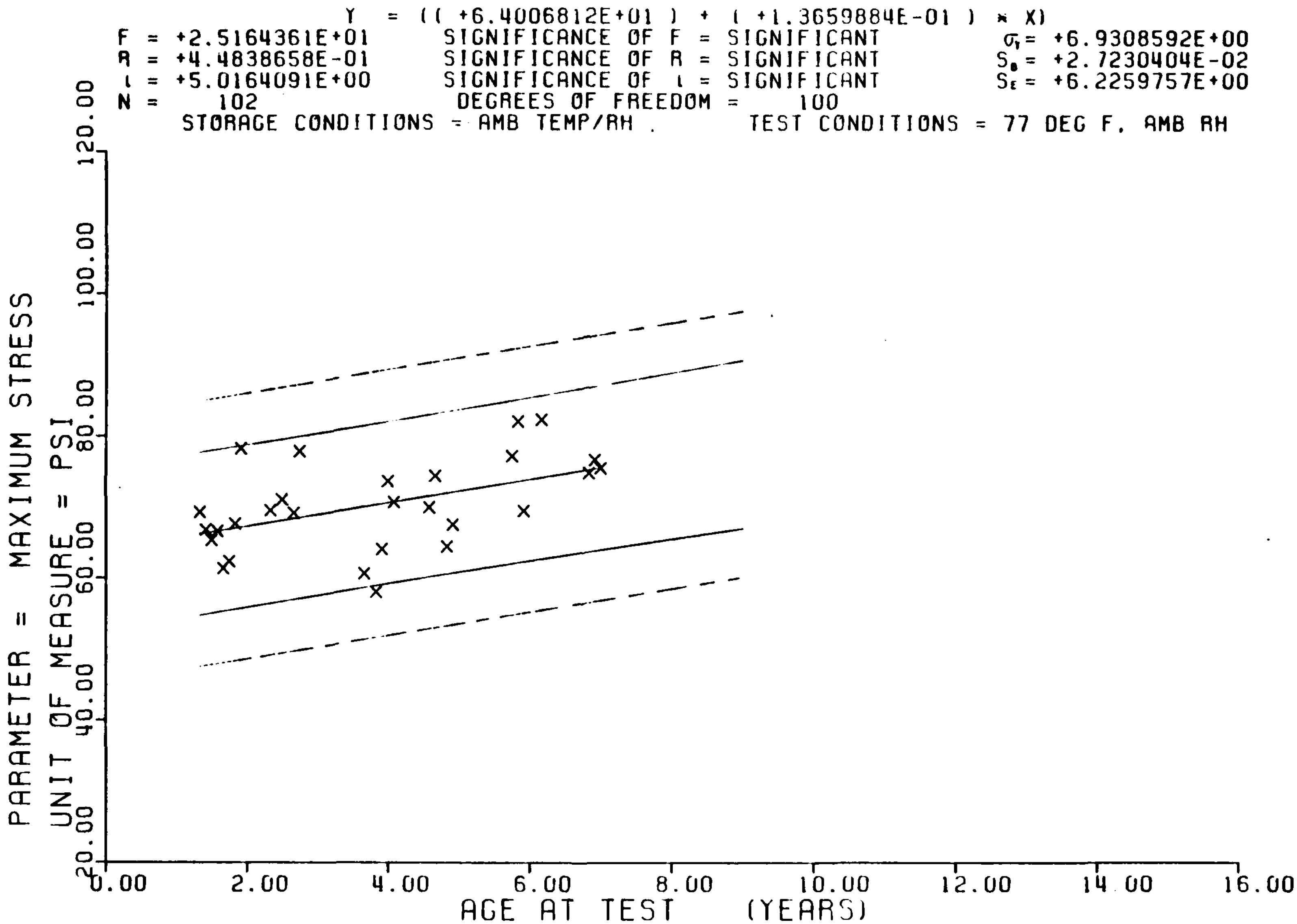
TENSILE STRAIN AT RUP, ANB-3066 PROPELLANT (ANB, G), .0002 IN/M, 77 D, UNLND CTN

Figure 4-5



TENSILE MODULUS, ANB-3066 PROPELLANT (ANB. CI, .0002 IN/MIN, 77 DEG F, UNLND CTN

Figure 4-6



TENSILE MAXIMUM STRESS, ANB-3066 (ANB G-POLYMER LINED), 0.0002 IN/MIN

Figure 4-7

Y = ((+1.7148252E-01) + (-2.3105857E-04) * X)

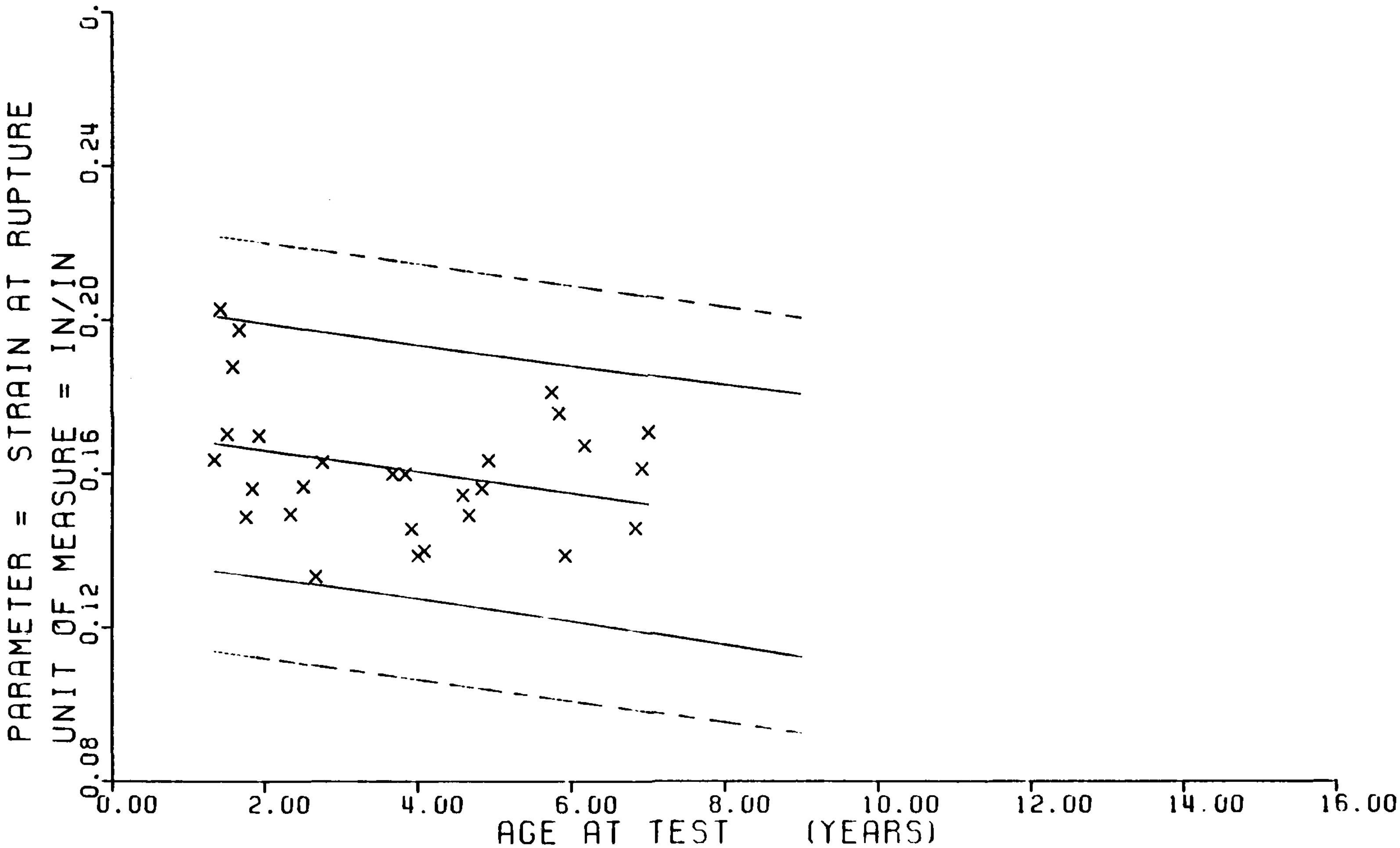
F = +8.6146256E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.8665545E-02

R = -2.8162684E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +7.8723408E-05

ι = +2.9350682E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +1.7999366E-02

N = 102 DEGREES OF FREEDOM = 100

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH

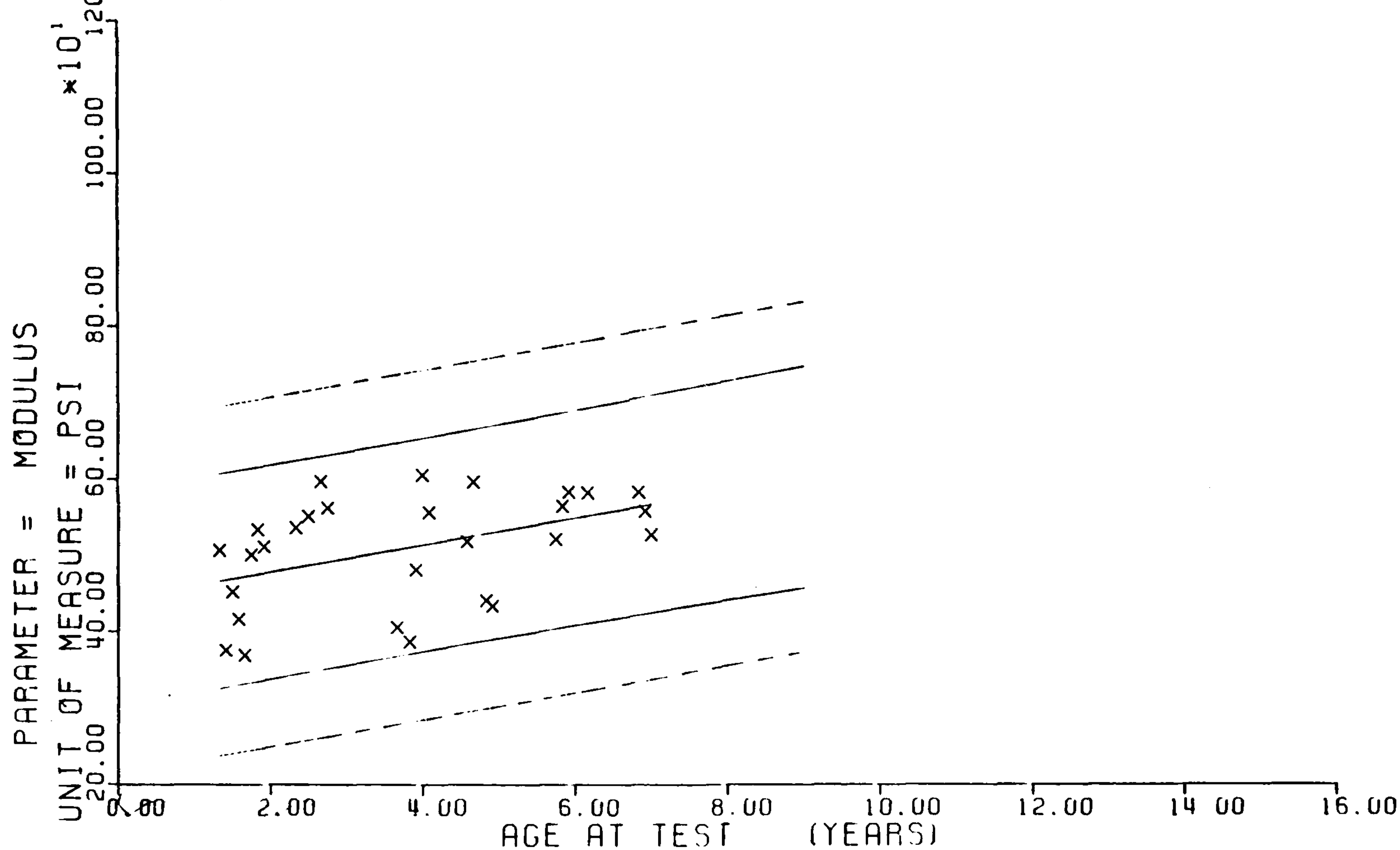


TENSILE RUPTURE STRAIN, ANB-3066 (ANB G-POLYMER LINED), 0.0002 IN/MIN

Figure 4-8

Y = ((+4.4245909E+02) + (+1.4757812E+00) * X)

F = +1.9512340E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +8.3053202E+01
R = +4.0576342E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.3409295E-01
ι = +4.4172774E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_ε = +7.6291226E+01
N = 101 DEGREES OF FREEDOM = 99
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE MODULUS, ANB-3066 (ANB 6-POLYMER LINED), 0.0002 IN/MIN

Figure 4-9

Y = ((+7.2604940E+01) + (+1.1220366E-01) * X)

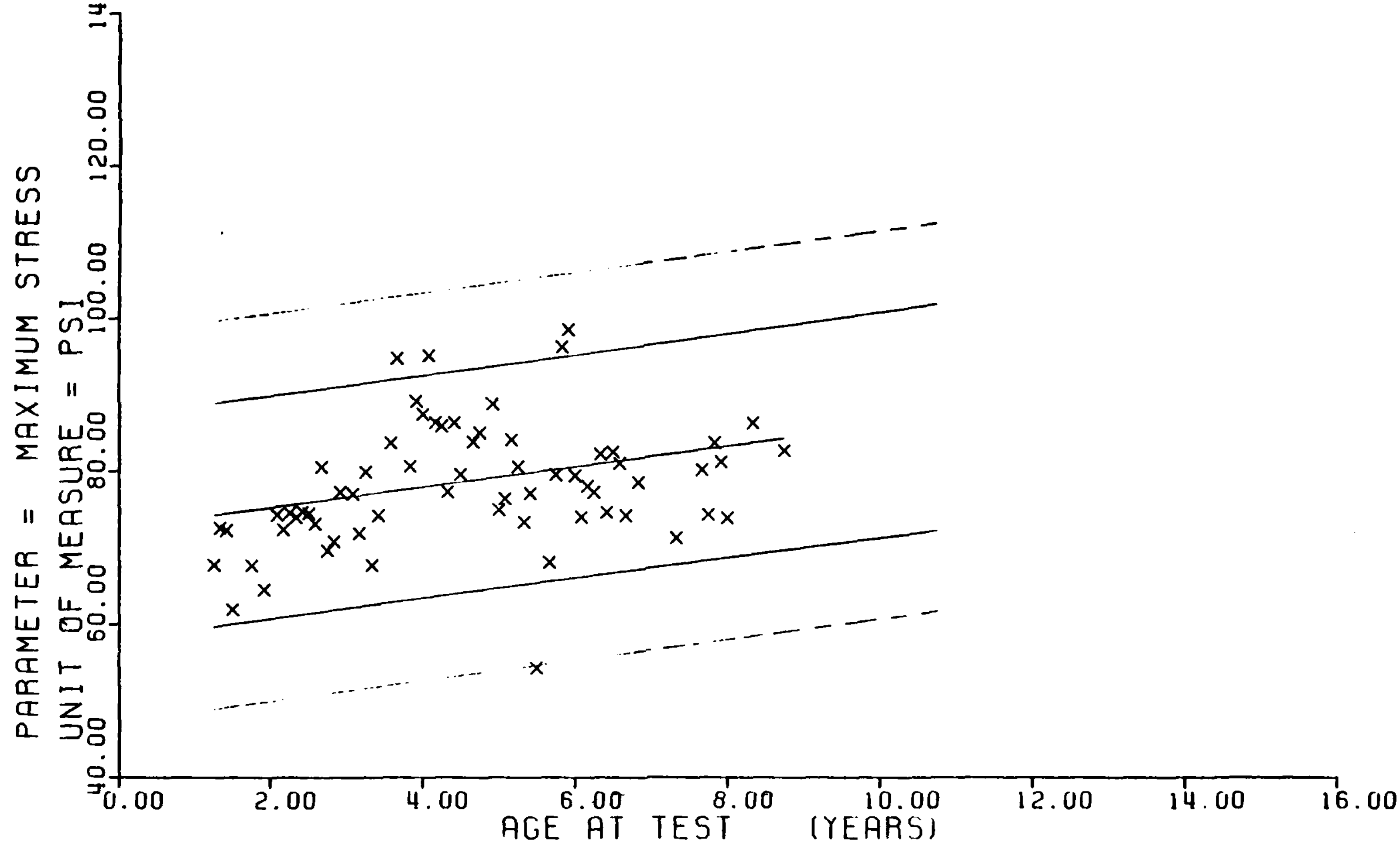
F = +3.5396971E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +8.7909107E+00

R = +2.7402466E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.8859230E-02

t = +5.9495354E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +8.4641079E+00

N = 438 DEGREES OF FREEDOM = 436

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F. AMB RH



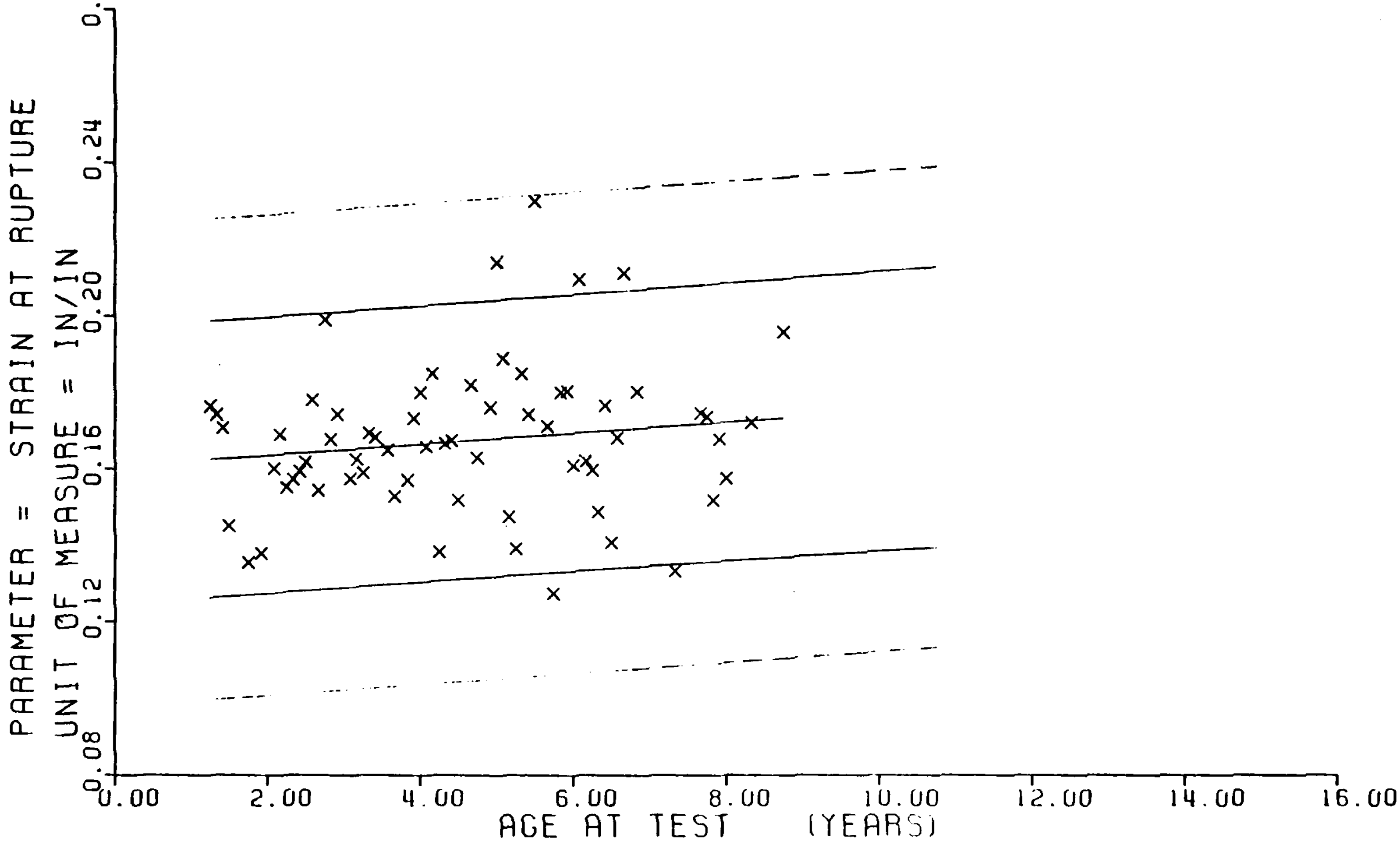
TENSILE MAX STRESS, ANB-3066 PROPELLANT(ANT). 0002 IN/MIN. 77 DEG F. UNLND CTN

Figure 4-10

Y = ((+1.6055019E-01) + (+1.2062650E-04) * X)

F = +6.6840400E+00   SIGNIFICANCE OF F = SIGNIFICANT σ_T = +2.1075925E-02
R = +1.2287756E-01   SIGNIFICANCE OF R = SIGNIFICANT S_a = +4.6657688E-05
t = +2.5853510E+00   SIGNIFICANCE OF t = SIGNIFICANT S_E = +2.0940181E-02
N = 438   DEGREES OF FREEDOM = 436

STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = 77 DEG F. AMB RH



TENSILE STRN AT RUP. ANB-3066 PROPELLANT(ANT). 0002 IN/MIN. 77 DEG F. UNLND CTN

Figure 4-11

Y = ((+5.2069203E+02) + (+1.0556951E+00) * X)

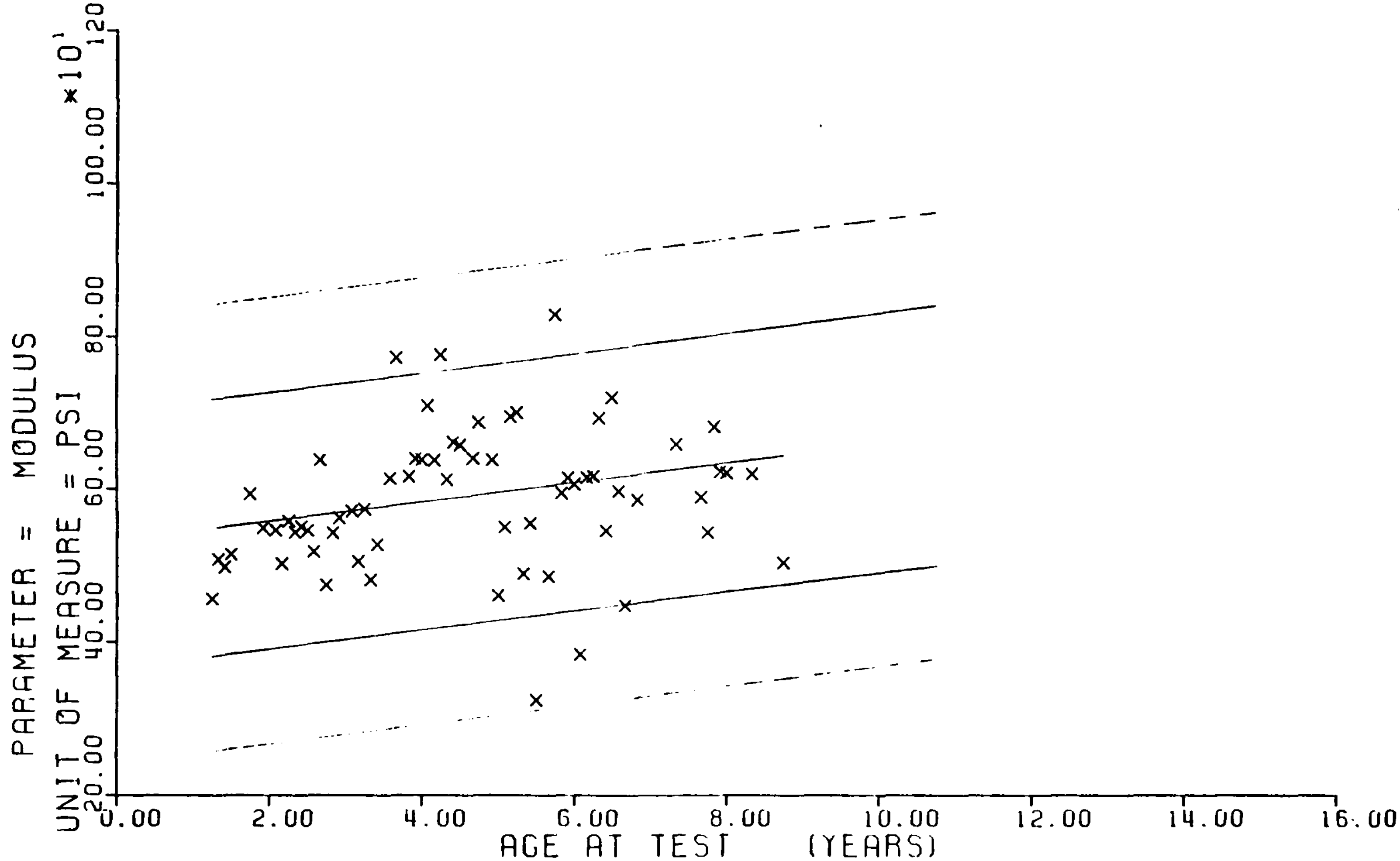
F = +2.3669530E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +9.9881038E+01

R = +2.2691957E-01 SIGNIFICANCE OF R = SIGNIFICANT S_b = +2.1699198E-01

t = +4.8651341E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +9.7386982E+01

N = 438 DEGREES OF FREEDOM = 436

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE MODULUS, ANB-3066 PROPELLANT (ANT), 0.0002 IN/MIN, 77 DEG F, UNLND CTN

Figure 4-12

Y = ((+7.8759763E+01) + (+1.1529107E-02) * X)

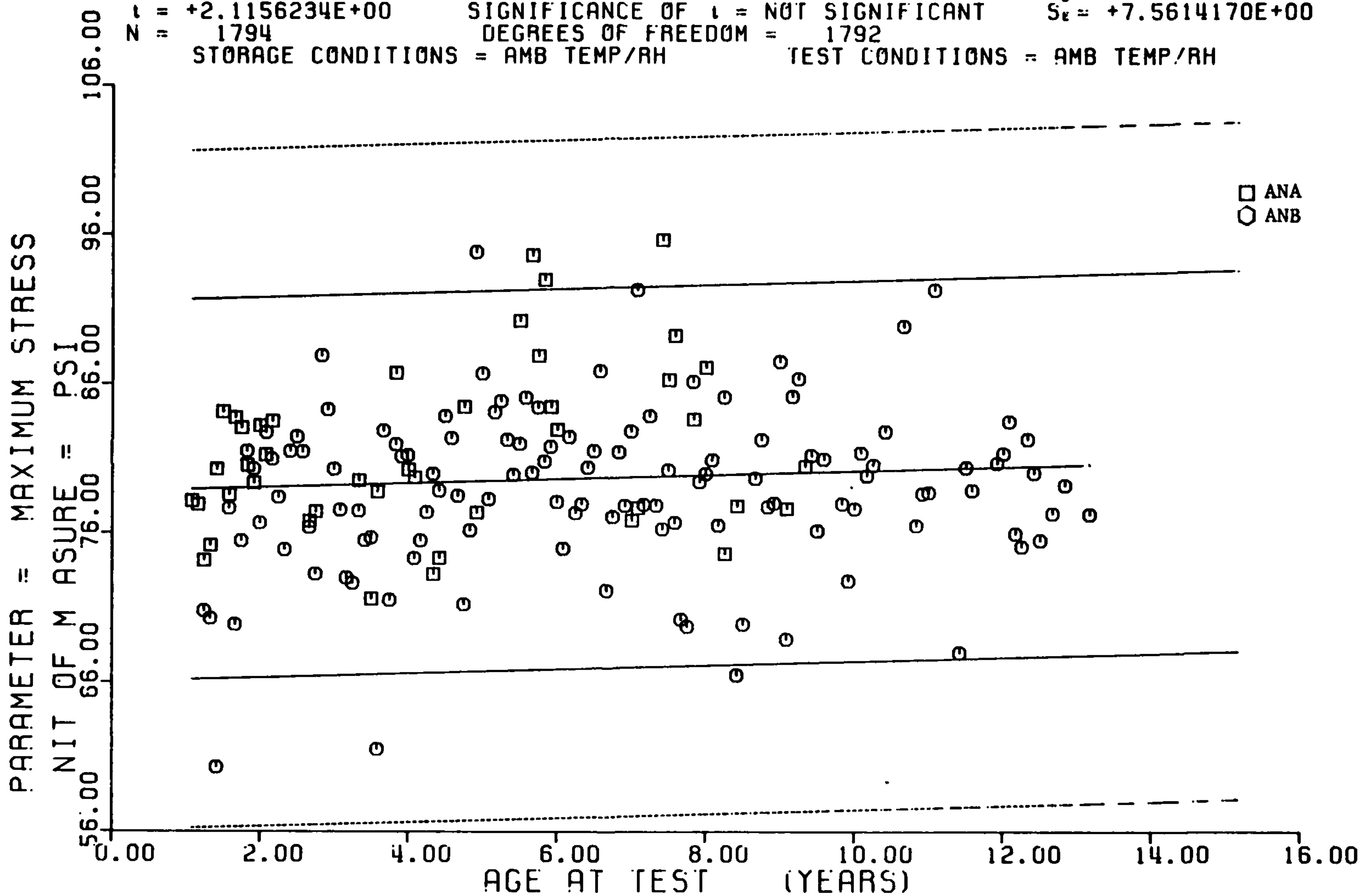
F = +4.4758627E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +7.5687426E+00

R = +4.9914610E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = +5.4495080E-03

t = +2.1156234E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_E = +7.5614170E+00

N = 1794 DEGREES OF FREEDOM = 1792

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE MAXIMUM STRESS, ANB-3066 (ANA-ANB G-POLY UNLND), 0.0002 IN/MIN

F.gure 4-13

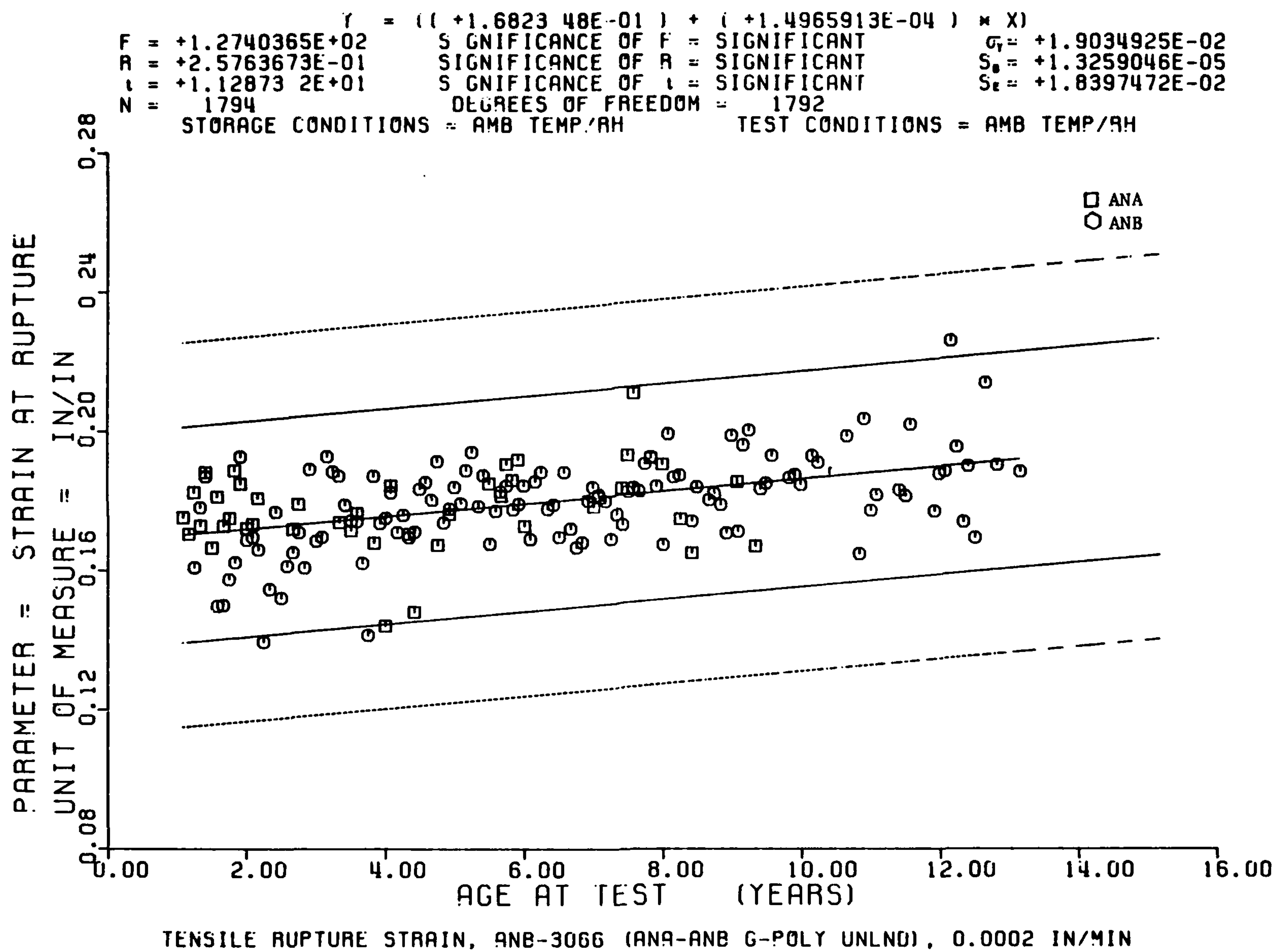
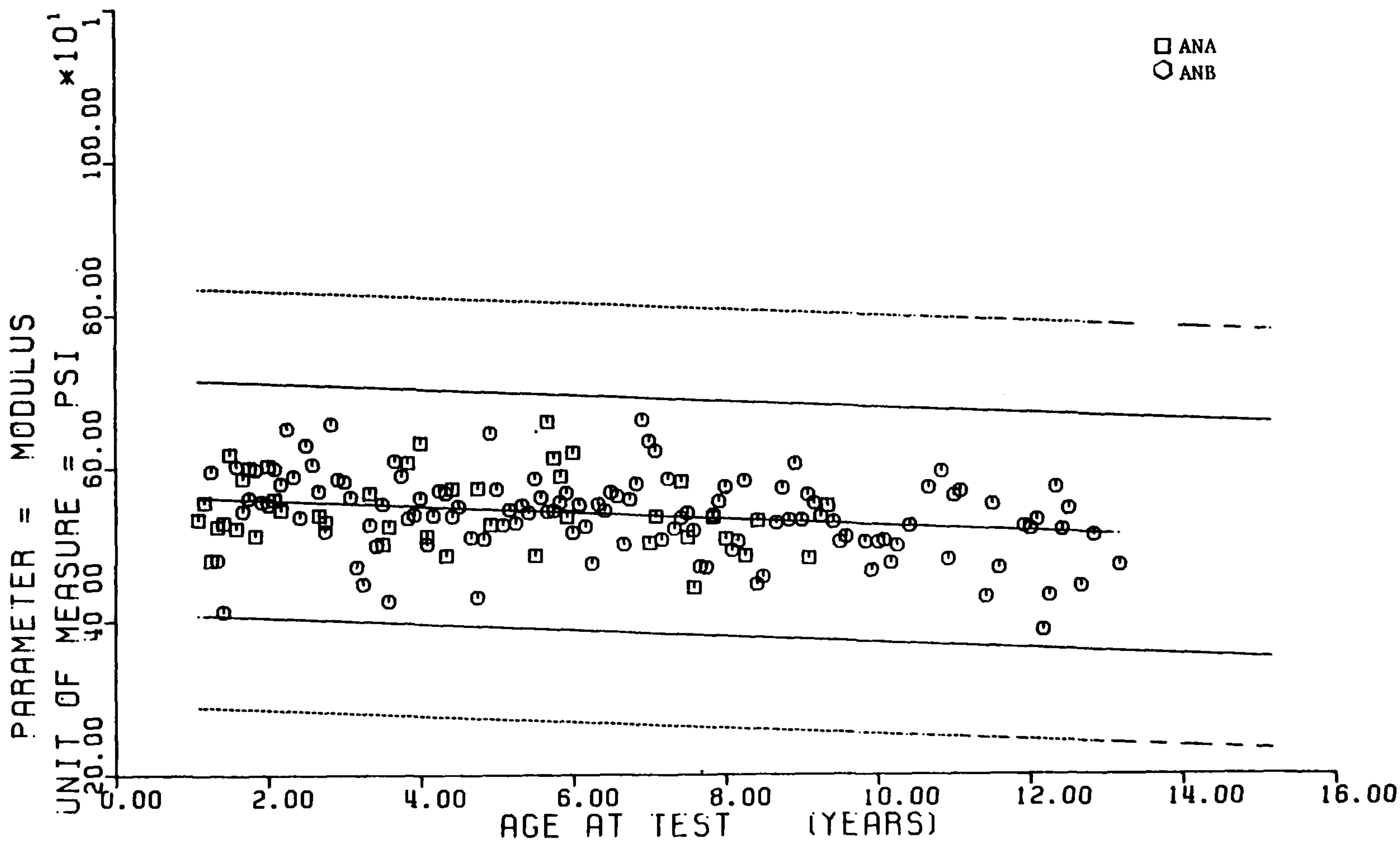

Y = ((+1.6823 48E-01) + (+1.4965913E-04) × X)
F = +1.2740365E+02
S GNIFICANCE OF F = SIGNIFICANT
σ_Y = +1.9034925E-02
R = +2.5763673E-01
SIGNIFICANCE OF R = SIGNIFICANT
S_B = +1.3259046E-05
t = +1.12873 2E+01
S GNIFICANCE OF t = SIGNIFICANT
S_E = +1.8397472E-02
N = 1794
DEGREES OF FREEDOM = 1792
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
ANA
ANB
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.08
0.12
0.16
0.20
0.24
0.28
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE RUPTURE STRAIN, ANB-3066 (ANA-ANB G-POLY UNLND), 0.0002 IN/MIN

Figure 4-14

Y = ((+5.6617370E+02) + (-3.3364575E-01) * X)

F = +2.5612051E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +9.1710133E+01
R = -1.1926017E-01 SIGNIFI ANCE OF R = SIGNIFICANT S_B = +6.5671108E-02
t = +5.0805562E+00 SIGNIFICANC OF t = SIGNIFICANT S_E = +9.1081046E+01
N = 1791 DE REES OF FREEDOM = 1789
STORAGE CONDITIONS = AMB TEMP/RH TES CONDITIONS = AMB TEMP/RH



TENSILE MODULUS, ANB-3066 (ANA-ANB G-POLY UNL D), 0.0002 IN/MIN

Figure 4-15

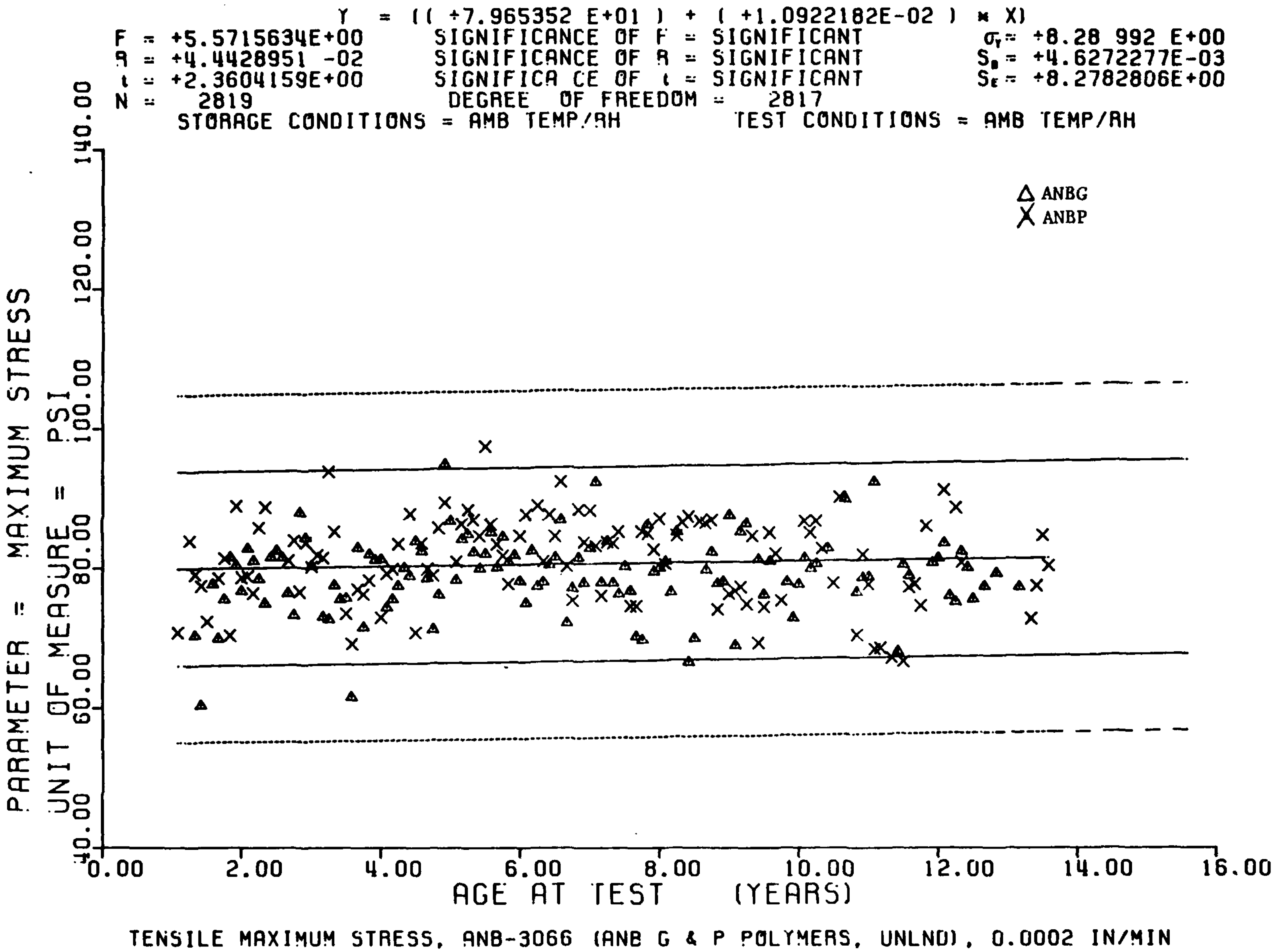
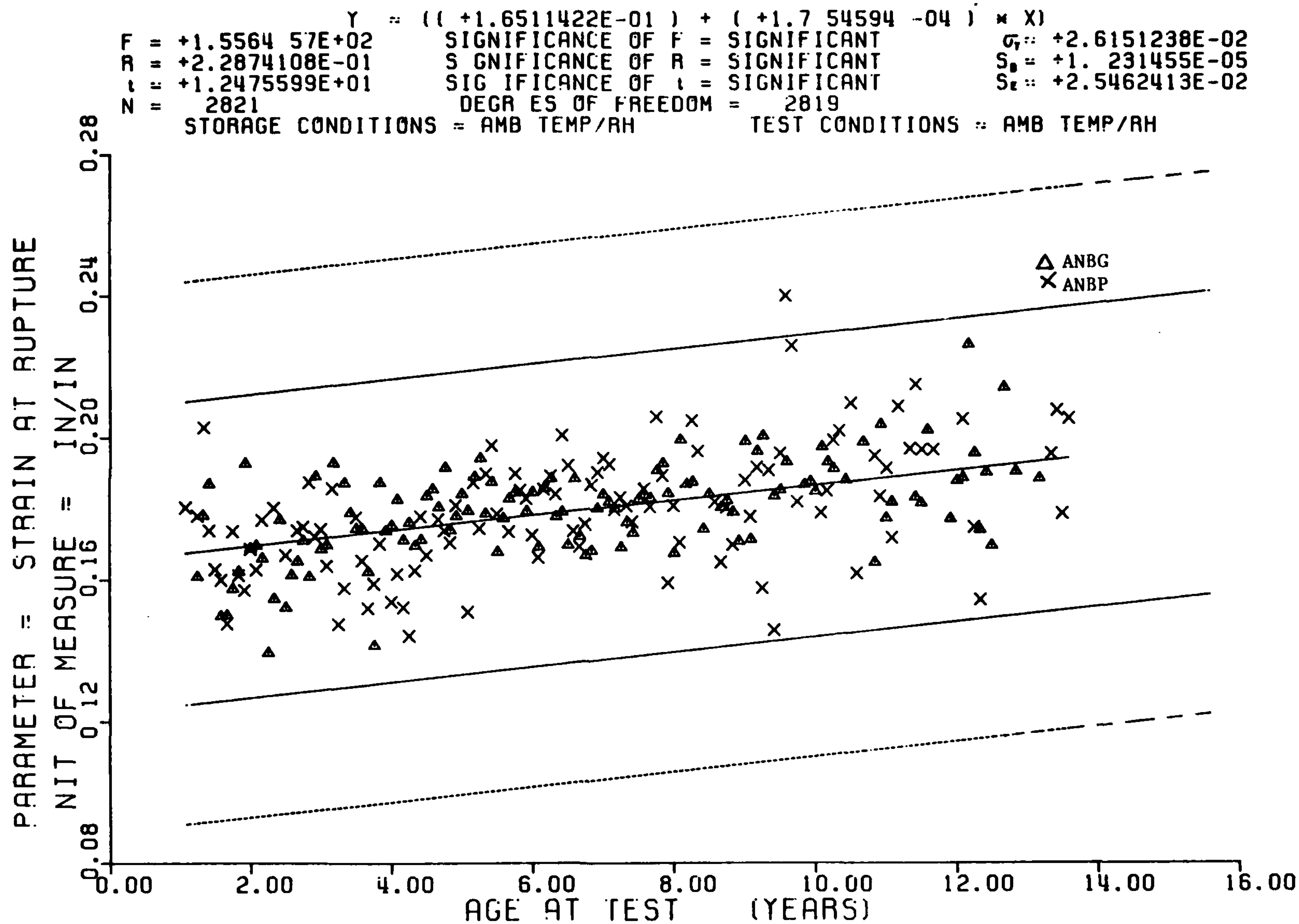

Y = ((+7.965352 E+01) + (+1.0922182E-02) * X)
F = +5.5715634E+00 SIGNIFICANCE OF F = SIGNIFICANT
R = +4.4428951 -02 SIGNIFICANCE OF R = SIGNIFICANT
t = +2.3604159E+00 SIGNIFICA CE OF t = SIGNIFICANT
N = 2819 DEGREE OF FREEDOM = 2817
σY = +8.28 992 E+00
SB = +4.6272277E-03
SE = +8.2782806E+00
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
ANBG
ANBP
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
140.00
120.00
100.00
80.00
60.00
40.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE MAXIMUM STRESS, ANB-3066 (ANB G & P POLYMERS, UNLND), 0.0002 IN/MIN

Figure 4-16



TENSILE RUPTURE STRAIN, ANB-3066 (ANB G & P POLYMERS, UNLND), 0.0002 IN/MIN

Figure 4-17

Y = ((+5.814 159E+02) + (-3.1655885E-01) * X)

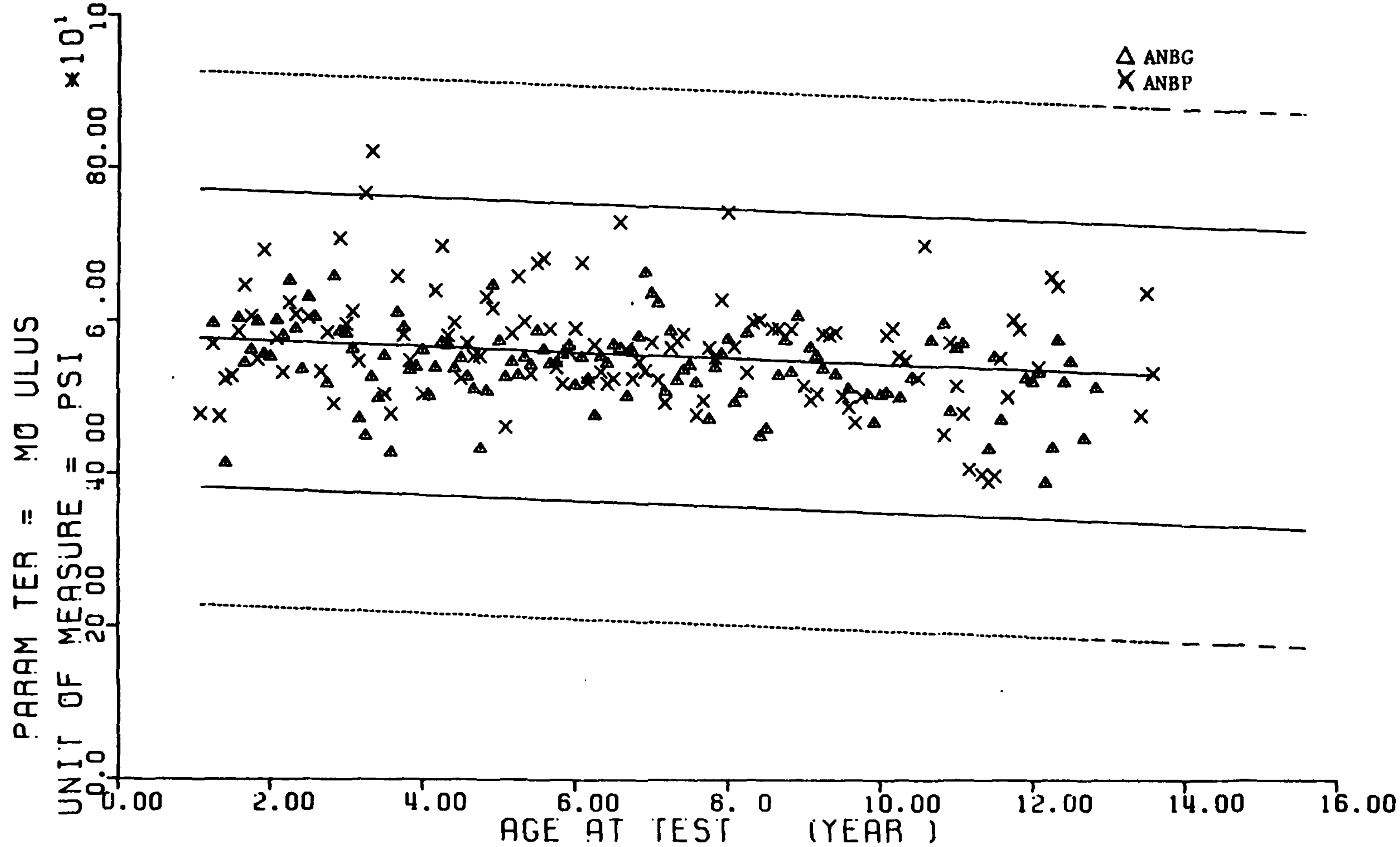
F = +2.3674 98E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.1685439E+02

R = -9.132 084E-02 SIGNIFICANCE OF R = SIGNIFICANT S_B = +6.5059589E-02

t = +4.8656755E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.1638675E+02

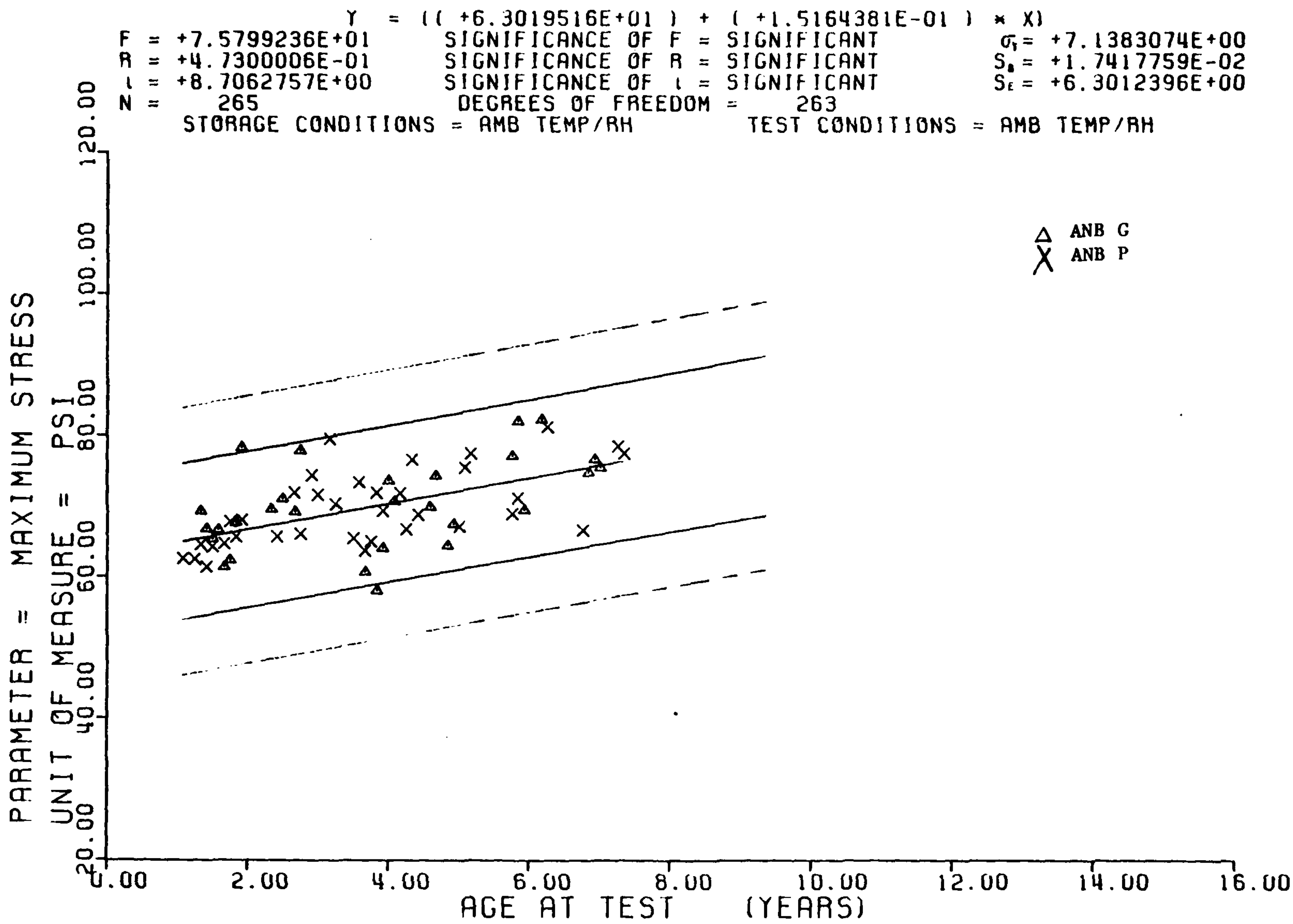
N = 2817 DEGREES OF F EEDOM = 2 15

STORAGE CONDITIO S = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



T NSIL MODULUS, ANB-3066 (ANB G & P POLYMERS, UNLND), 0.0002 IN/MIN

Figure 4-18



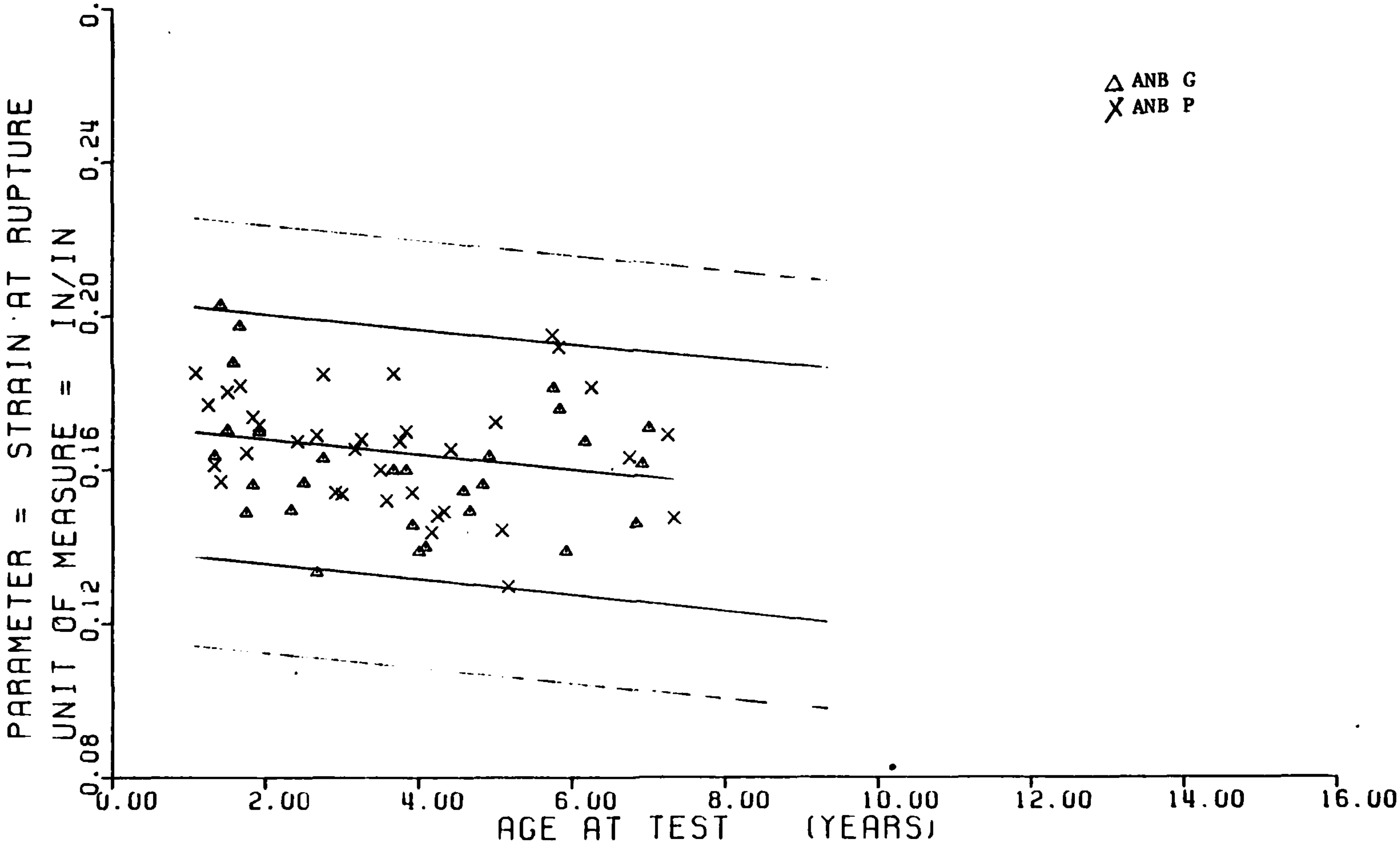
TENSILE MAXIMUM STRESS, ANB-3066 (ANB G & P POLYMERS LINED), 0.0002 IN/MIN

Figure 4-19

Y = ((+1.7193540E-01) + (-1.0597231E-04) * X)

F = +1.0468068E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.8888063E-02
R = -1.9565004E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +5.1298230E-05
t = +3.2354393E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.8558209E-02
N = 265 DEGREES OF FREEDOM = 263

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE RUPTURE STRAIN, ANB-3066 (ANB G & P POLYMERS LINED), 0.0002 IN/MIN

Figure 4-20

Y = ((+4.3931214E+02) + (+1.3056240E+00) * X)

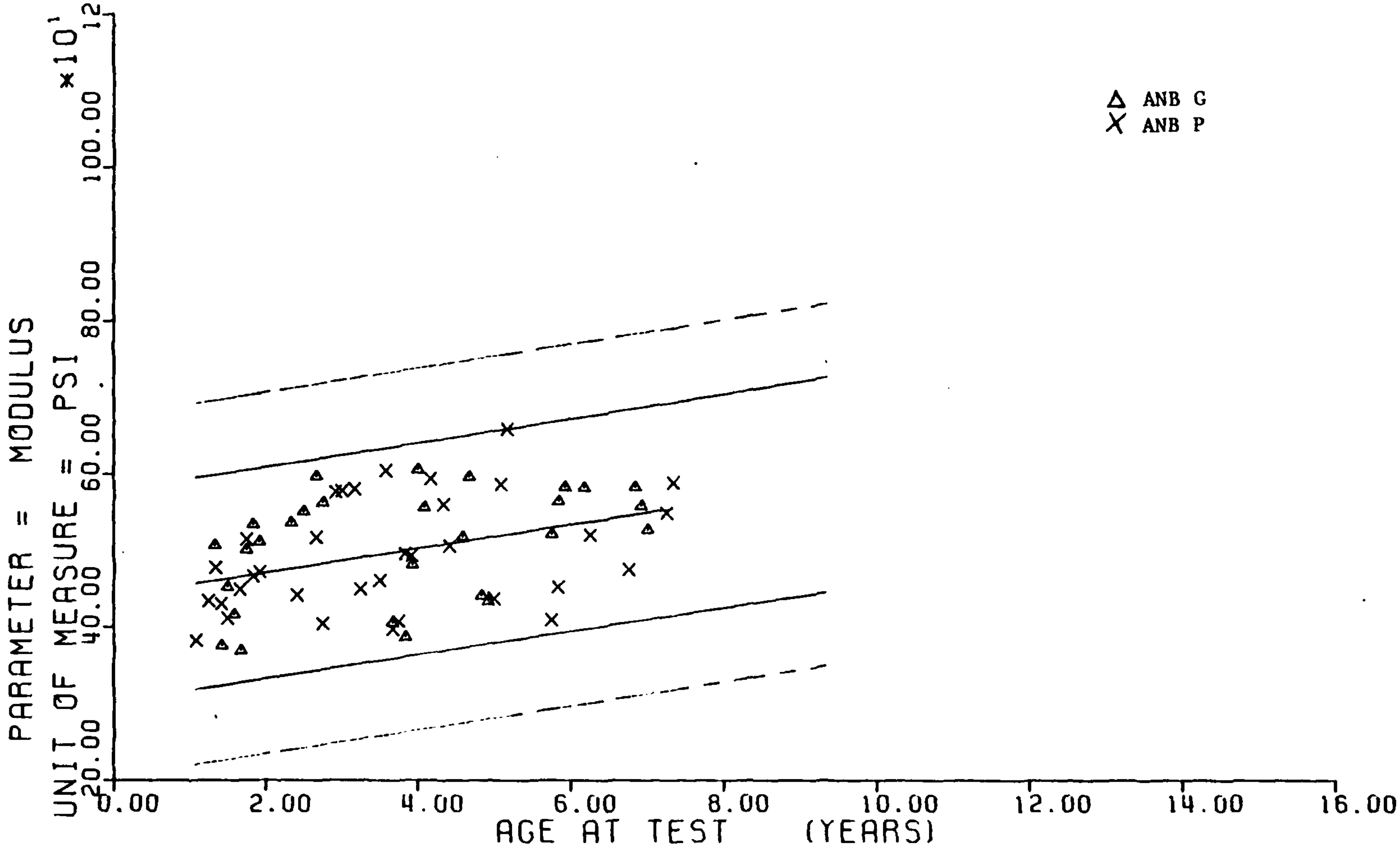
F = +3.5595194E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +8.3788591E+01

R = +3.4938600E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.1883785E-01

ι = +5.9661708E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +7.8661326E+01

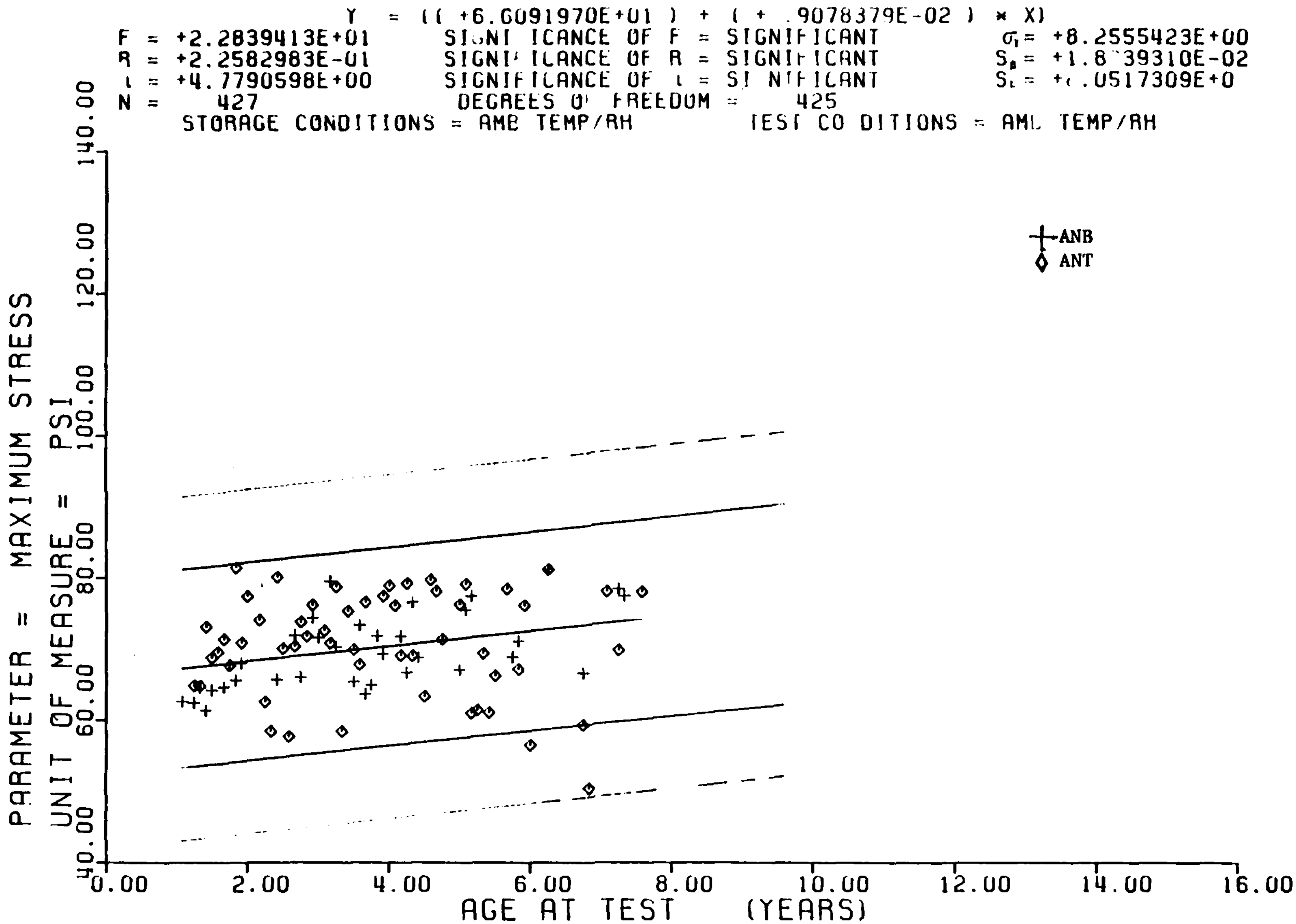
N = 258 DEGREES OF FREEDOM = 256

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



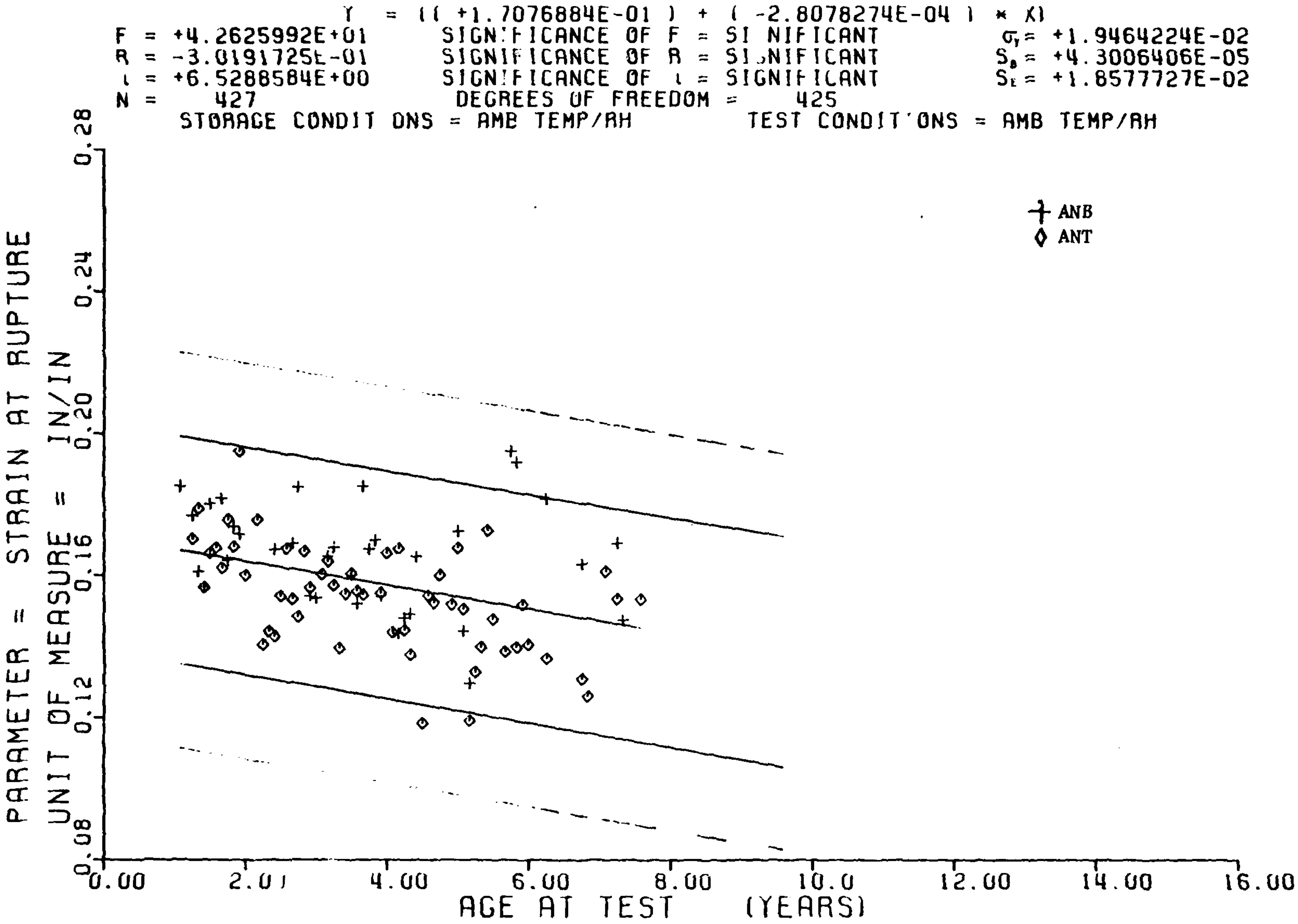
TENSILE MODULUS, ANB-3066 (ANB G & P POLYMERS LINED), 0.0002 IN/MIN

Figure 4-21



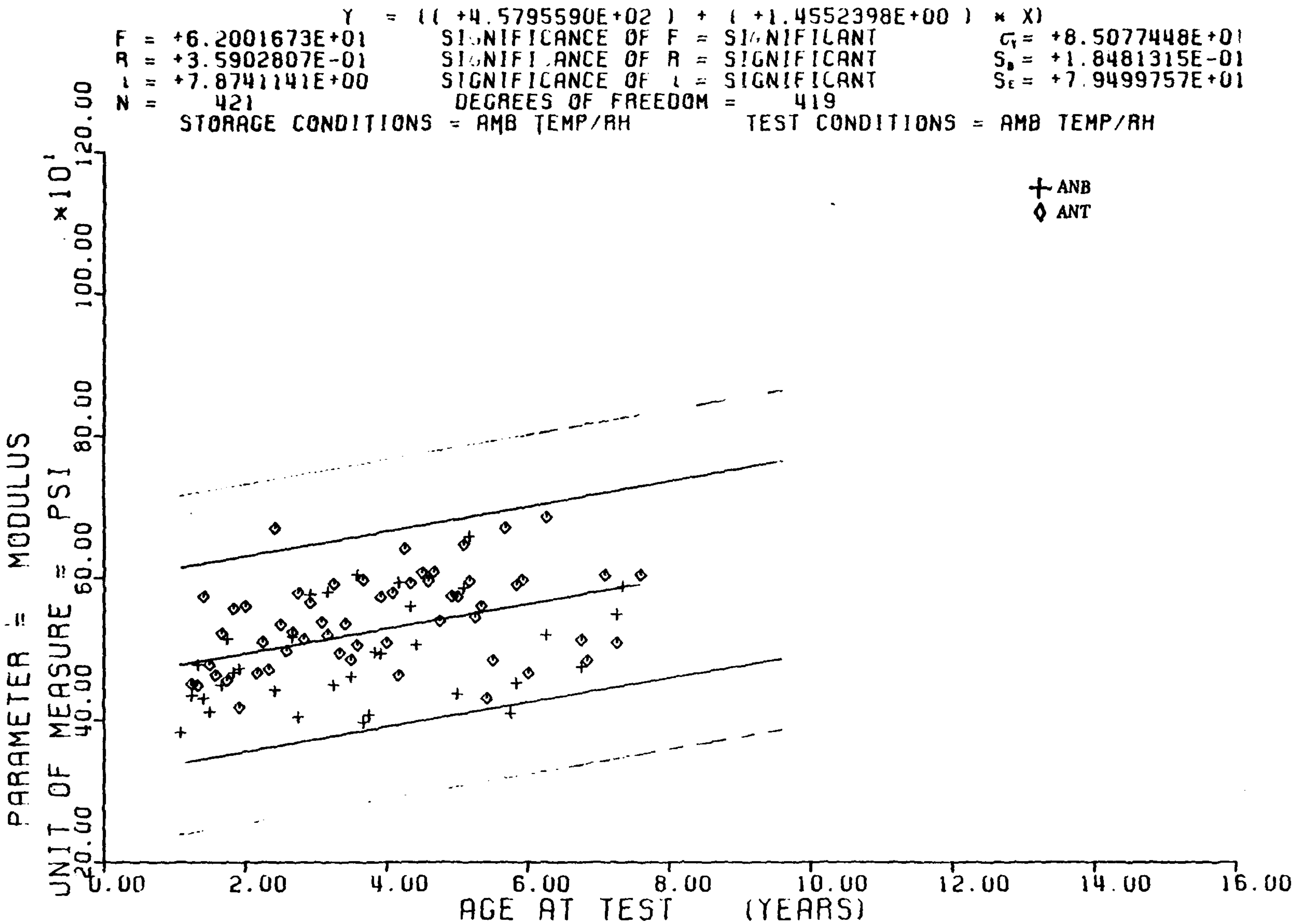
TENSILE MAXIMUM STRESS, ANB-3066 (ANT & ANB P POLYMER LI ED), 0.0002 I /MIN

Figure 4-22



TENSILE RUPTURE STRAIN, ANB-3066 (ANT & ANB P POLYMER LINED), 0.0002 IN/MIN

Figure 4-23



TENSILE MODULU , ANB-3066 (ANT & ANB P-POLYMER LINED), 0.0002 IN MI

Figure 4-24

SECTION V

HIGH RATE TENSILE

A. HIGH RATE TRIAXIAL:

This test utilizes a specimen 3/4 inch (1.9 cm) GL rail by 5 inches (12.7 cm) long. The specimens are tested on the MTS at a crosshead speed of 1750 in/min (74.08 cm/sec) with 600 psi (42.18 kg/sq cm). Strain rate is 1000 in/in/min. These conditions simulate that of the motor at ignition.

There are fewer significant trends than in the last report. Lined cartons of ANB"G" and ANT"P" propellant show significant trends for all parameters but in opposing directions (Table 5-1).

The most consistent statistical feature of the test is the lower standard deviation of lined cartons compared to unlined cartons (Table 2-1). This characteristic is most noticeable in the standard deviation of modulus which may be less than half that of unlined cartons. Since determination of a consistent modulus has been a problem in high rate testing, the much reduced deviation in lined cartons seems all the more remarkable.

B. HIGH RATE DOGBONES:

This test is performed under the same conditions as the rail specimens. The specimens are shortened dogbones with a nominal gage length of 0.75".

All systems show a significant increase in maximum stress. Modulus shows a significant increase except for ANB"P" lined cartons. Only ANT P and ANB G lined cartons do not show a significant decrease in strain and rupture (Table 5-2).

TABLE 5-1

HIGH RATE TRIAXIAL

Significance Of Regression Slopes

SYSTEM	Sm	Fig	er	Fig	E	Fig
ANA G Unlined	NS		Sig inc		Sig dec	
ANB G Unlined	NS		Sig inc		Sig dec	
ANB G Lined	Sig dec	5-1	Sig inc	5-2	Sig dec	5-3
ANB P Unlined	NS		NS		Sig dec	
ANB P Lined	NS		NS		NS	
ANT P Unlined	Sig inc		NS		NS	
ANT P Lined	Sig inc	5-4	Sig dec	5-5	Sig inc	5-6
ANA & ANB G Unlined	NS		Sig Inc		Sig dec	
ANB G&P Unlined	Sig inc	5-7	Sig inc	5-8	Sig dec	5-9
ANB G&P Lined	NS		NS		NS	
ANT & ANB P Unlined	NS		Sig dec		NS	
ANT & ANB P LINED	Sig inc	5-10	Sig dec	5-11	Sig inc	5-12

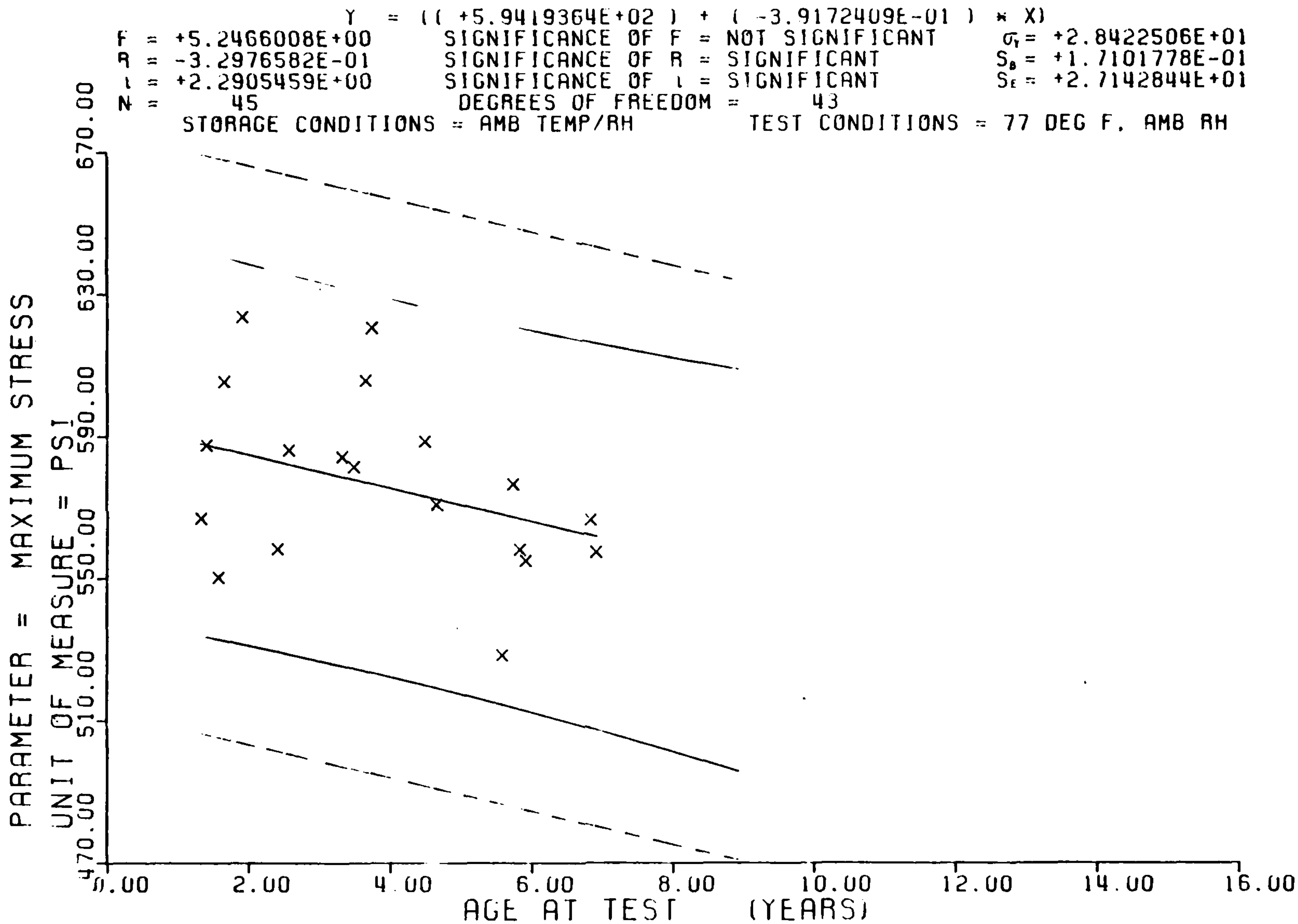
TABLE 5-2

HIGH RATE DOGBONES

Significance of Regression Slopes

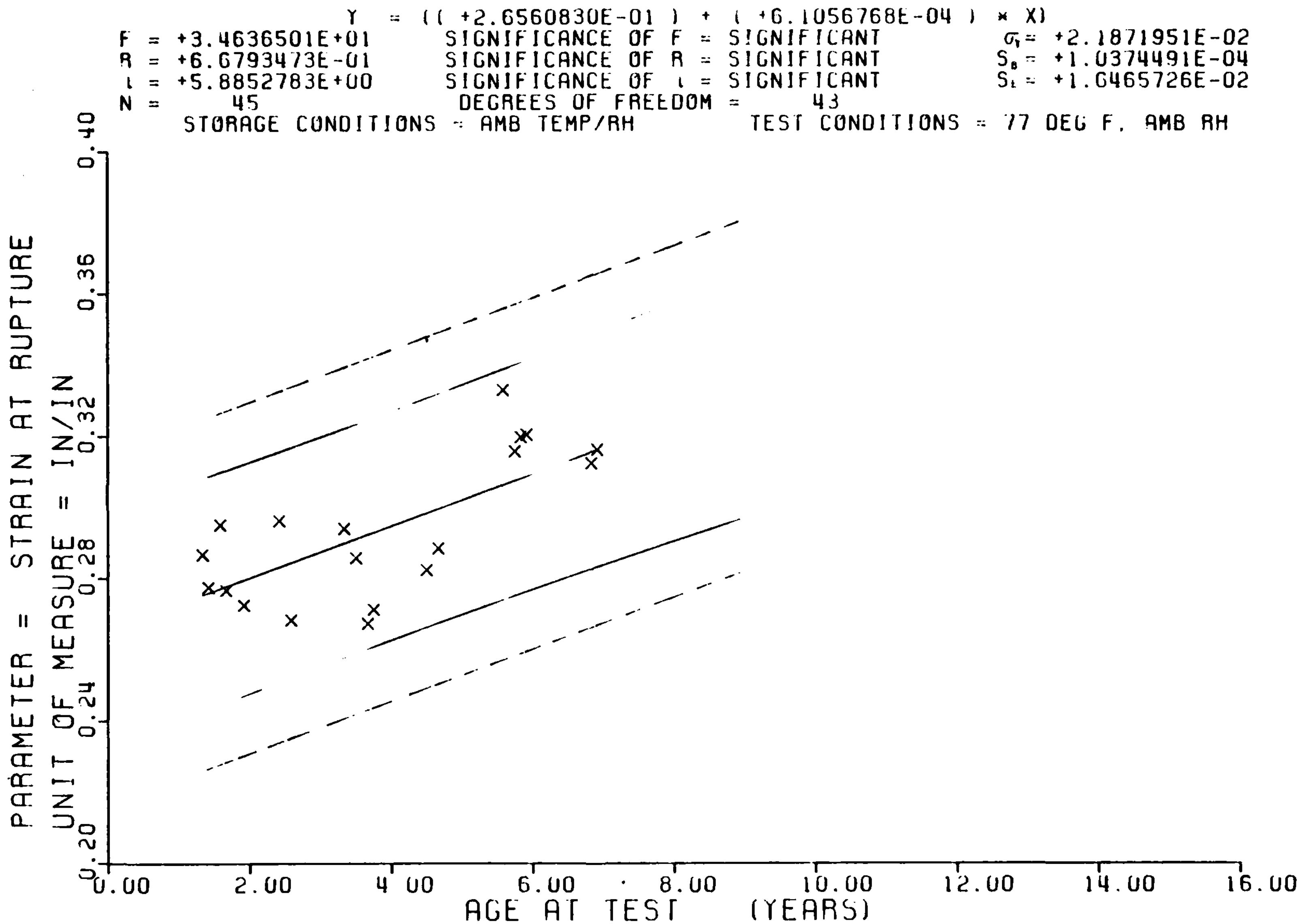
SYSTEM	sm	Fig	er	Fig	E	Fig
ANA G Unlined no data						
ANB G Unlined	Sig inc	5-13	Sig dec	5-14	Sig inc	5-15
ANB G Lined	Sig inc		NS		Sig inc	
ANB P Unlined	Sig inc	5-6	Sig dec	5-17	Sig inc	5-18
ANB P Lined	Sig inc		Sig dec		NS	
ANT P Unlined	Sig inc		NS		Sig inc	
ANT P Lined	Sig inc	5-19	Sig dec	5-20	Sig inc	5-21

NS = Not significantly different from zero slope
Sig inc = Positive slope
Sig dec = Negative slope



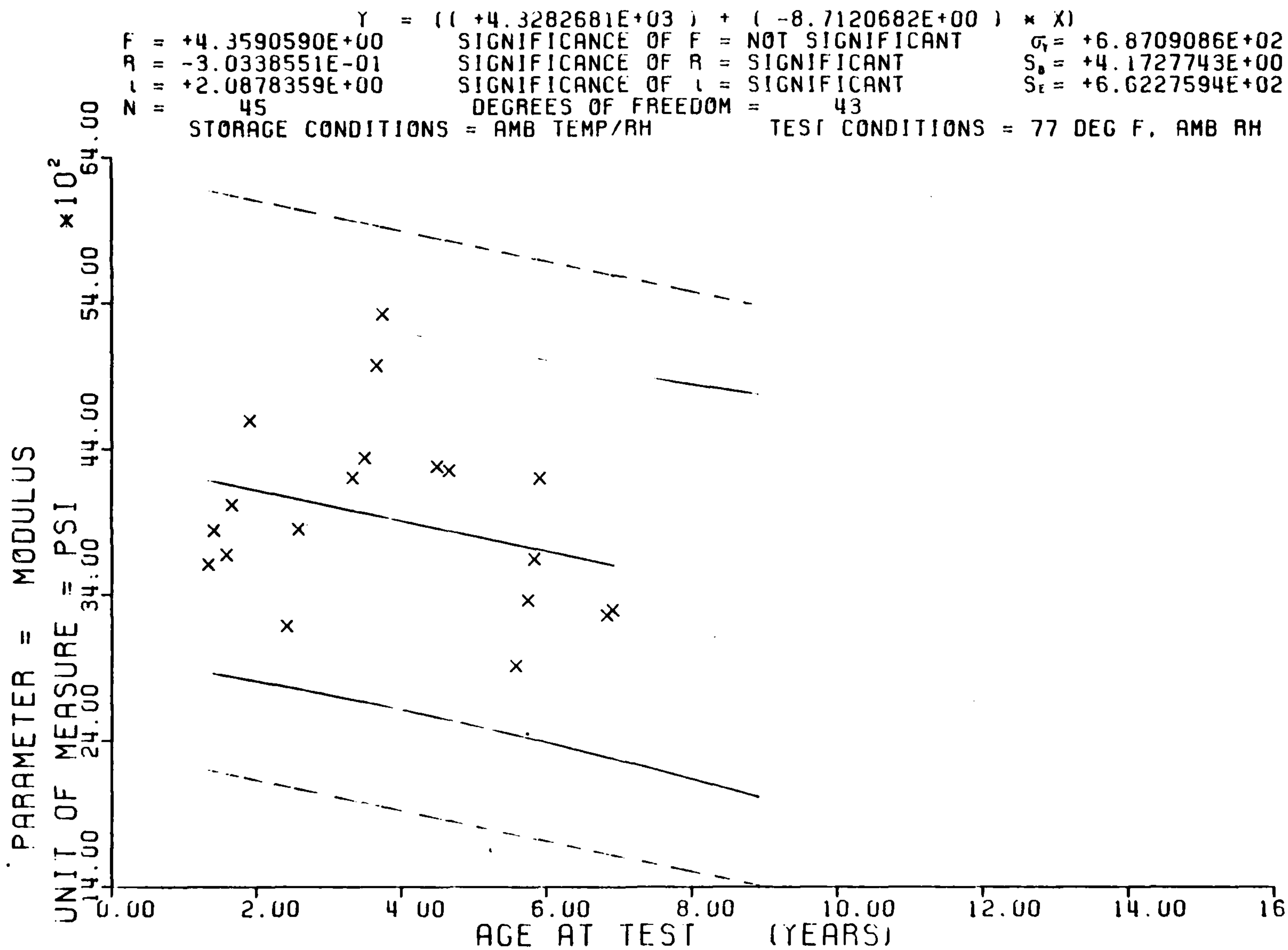
TENSILE TRIAX MAX STRESS, ANB-3066 (ANB G-POLYMER LINED), 1750 IN/MIN, 000 PSI

Figure 5-1



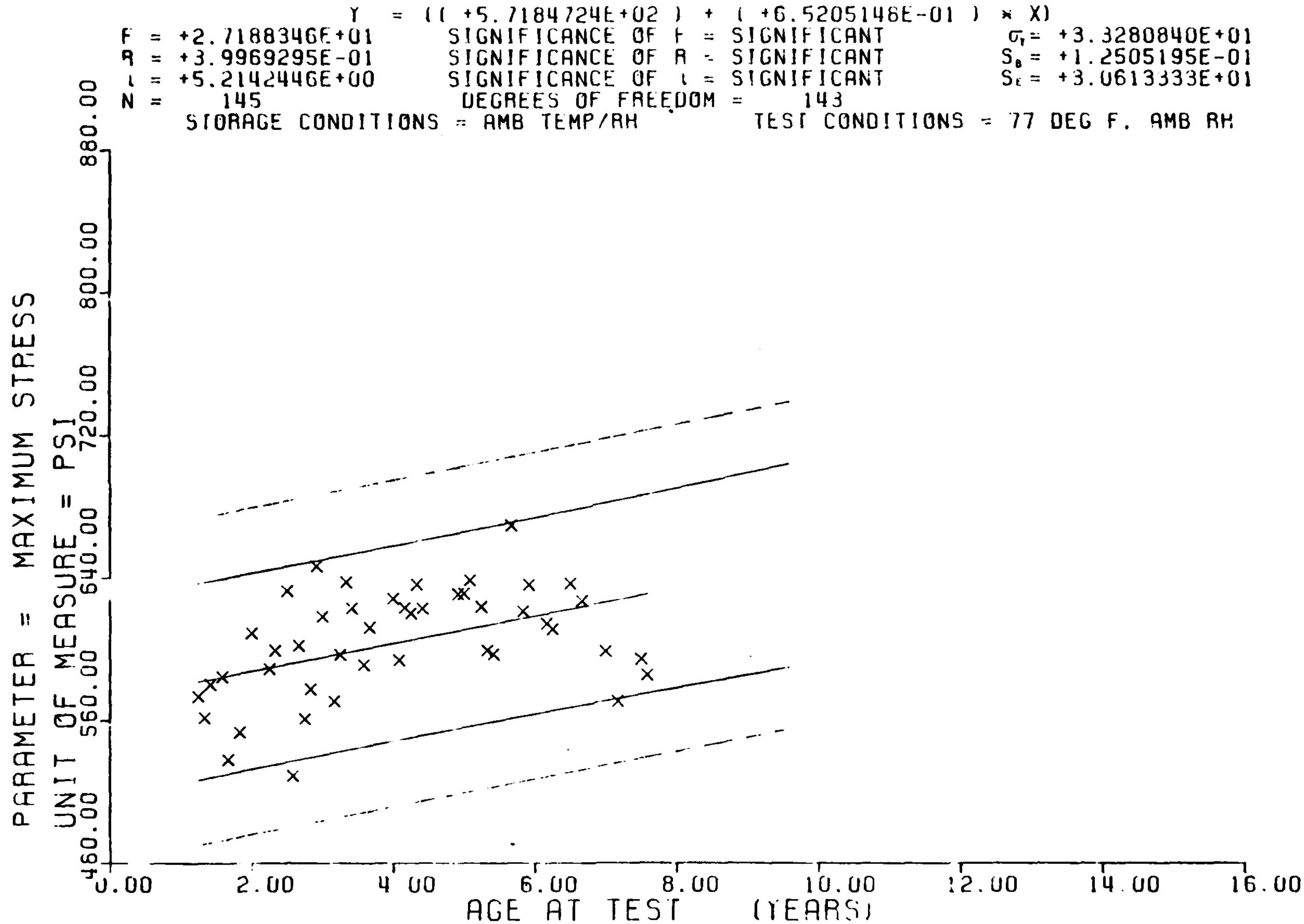
TENSILE TRIAX RUP STRAIN, ANB-3066 (ANB G-POLYMER LINED), .750 IN/MIN, 600 PSI

Figure 5-2



TENSILE TRIAXIAL MODULUS, 9NB-3066 (ANB G-POLYMER LINED), 1750 IN/MIN, 600 PSI

Figure 5-3



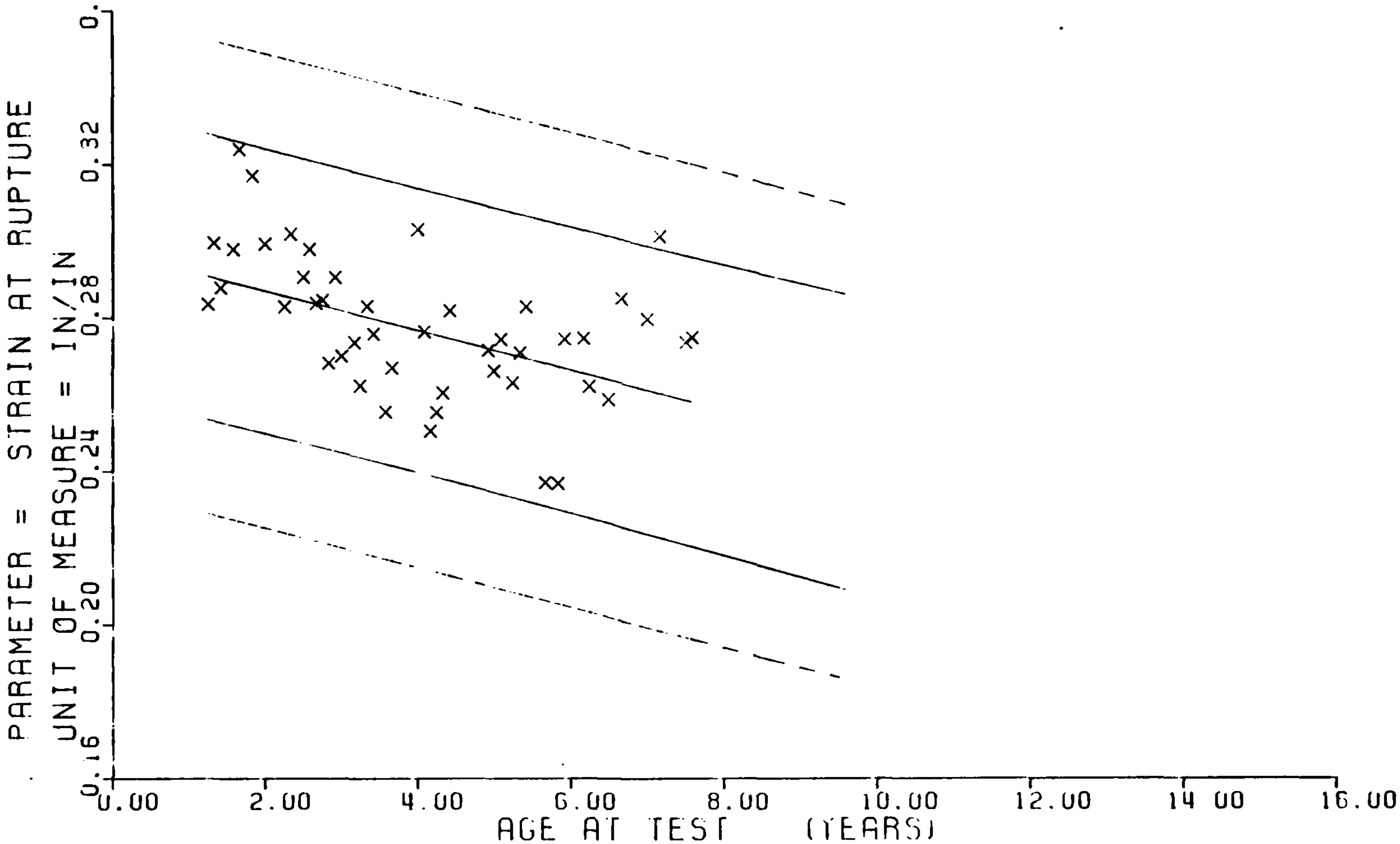
TENSILE TRIAX MAX STRESS, ANB-3066 (HNT P-POLYMER LINED), 1750 IN/MIN, 600 PSI

Figure 5-4

Y = ((+2.9737661E-01) + (-4.3303815E-04) * X)

F = +2.6236531E+01   SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +2.2311543E-02
R = -3.9490538E-01   SIGNIFICANCE OF R = SIGNIFICANT S_B = +8.4542084E-05
t = +5.1221608E+00   SIGNIFICANCE OF t = SIGNIFICANT S_E = +2.0570150E-02
N = 144   DEGREES OF FREEDOM = 142

STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = 77 DEG F, AMB RH

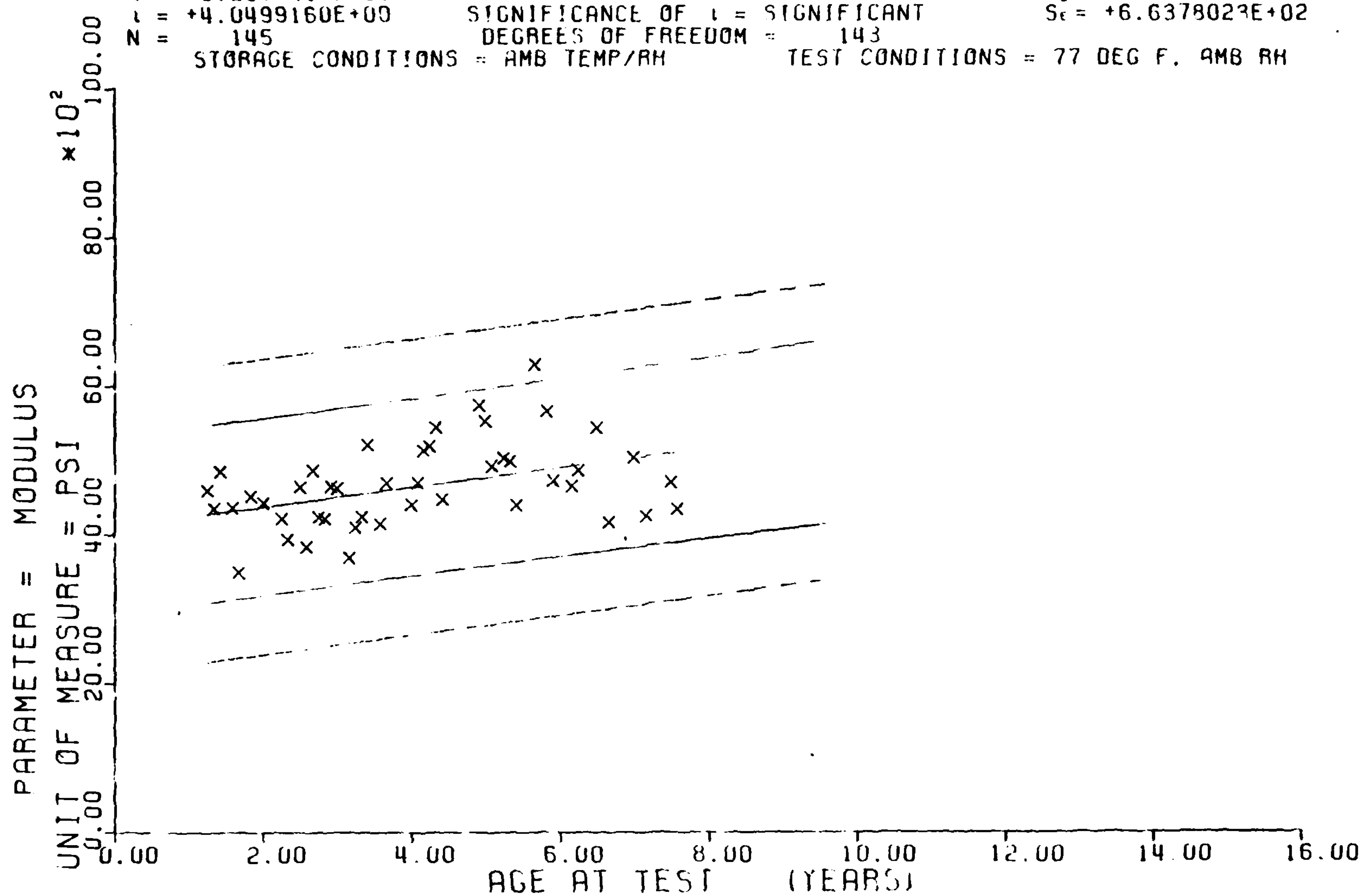


TENSILE TRIAX RUP STRAIN, ANB-3066 (ANT P-POLYMER LINED), 1750 IN/MIN, 600 PSI

Figure 5-5

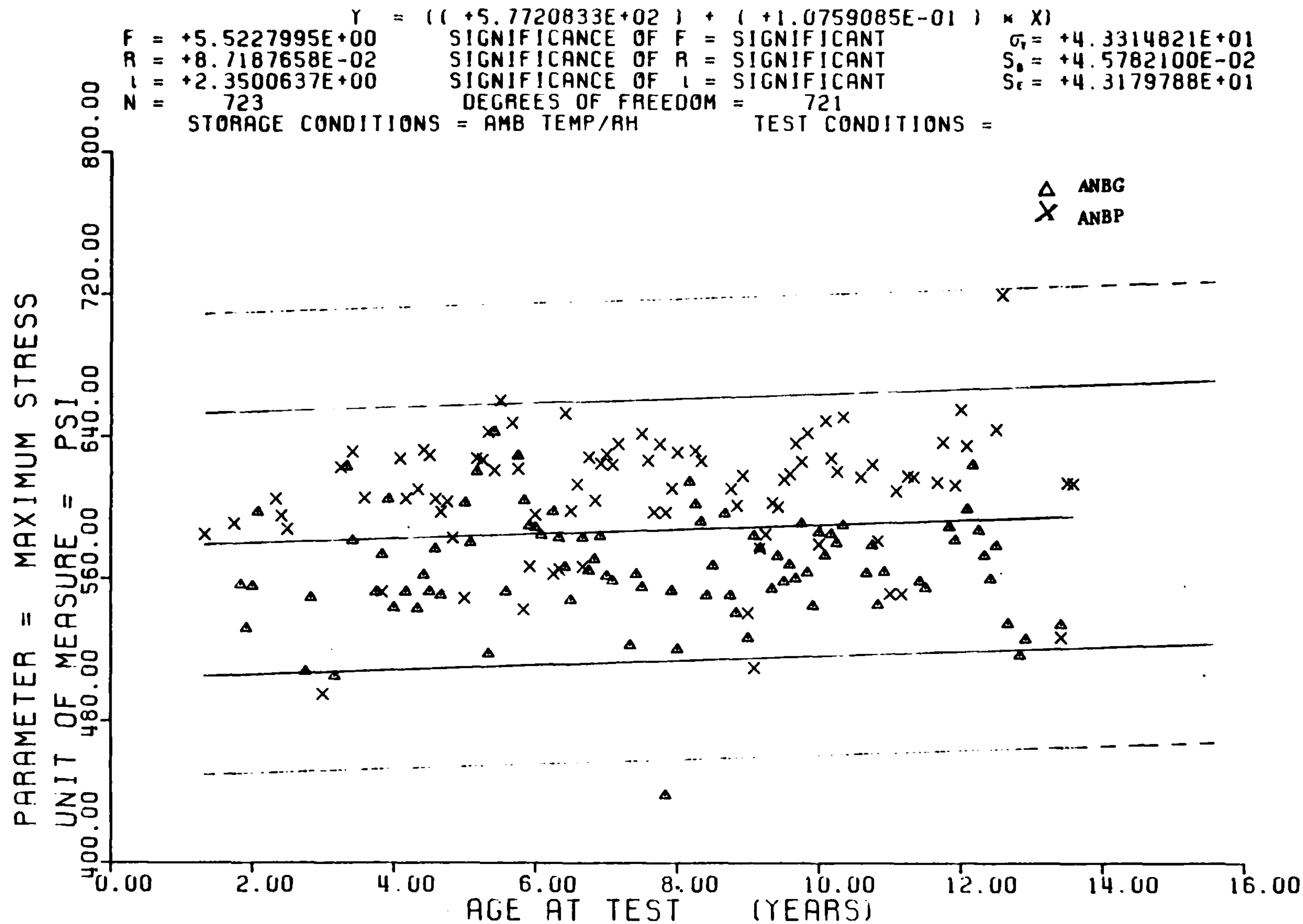
Y = ((+4.1077666E+03) + (+1.0981210E+01) * X)

F = +1.6401820E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_1 = +6.9837665E+02
R = +3.2077416E-01 SIGNIFICANCE OF R = SIGNIFICANT S_b = +2.7114660E+00
t = +4.0499160E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +6.6378023E+02
N = 145 DEGREES OF FREEDOM = 143
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F. AMB RH



TENSILE TRIAXIAL MODULUS. ANB-3066 (ANT P-POLYMER LINED). 1/50 IN/MIN. 600 PSI

Figure 5-6



TENSILE TRIAX MAX STRESS, ANB-3066 (ANB G & P POLY UNLINED), 1750 IN/M, 600 PSI

Figure 5-7

Y = ((+2.5192747E-01) + (+1.5473627E-04) * X)

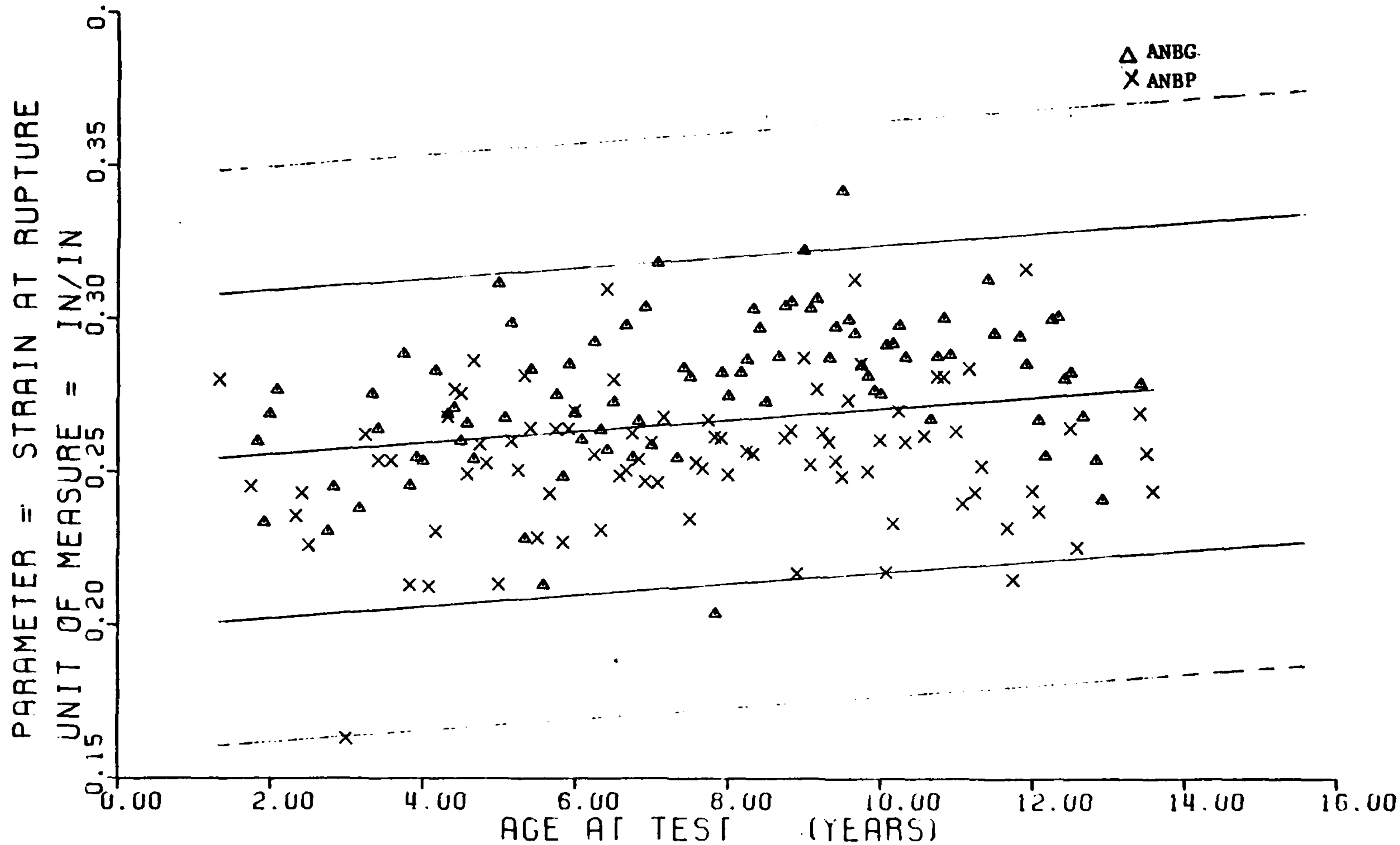
F = +2.1772038E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_1 = +3.1723898E-02

R = +1.7120710E-01 SIGNIFICANCE OF R = SIGNIFICANT S_b = +3.3162142E-05

ι = +4.6660516E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +3.1277164E-02

N = 723 DEGREES OF FREEDOM = 721

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE TRIAX RUP STRAIN, ANB-3066 (ANB G & P POLY UNLINED), 1750 IN/M, 600 PSI

Figure 5-8

Y = ((+6.1686943E+03) + (-1.0932099E+01) * X)

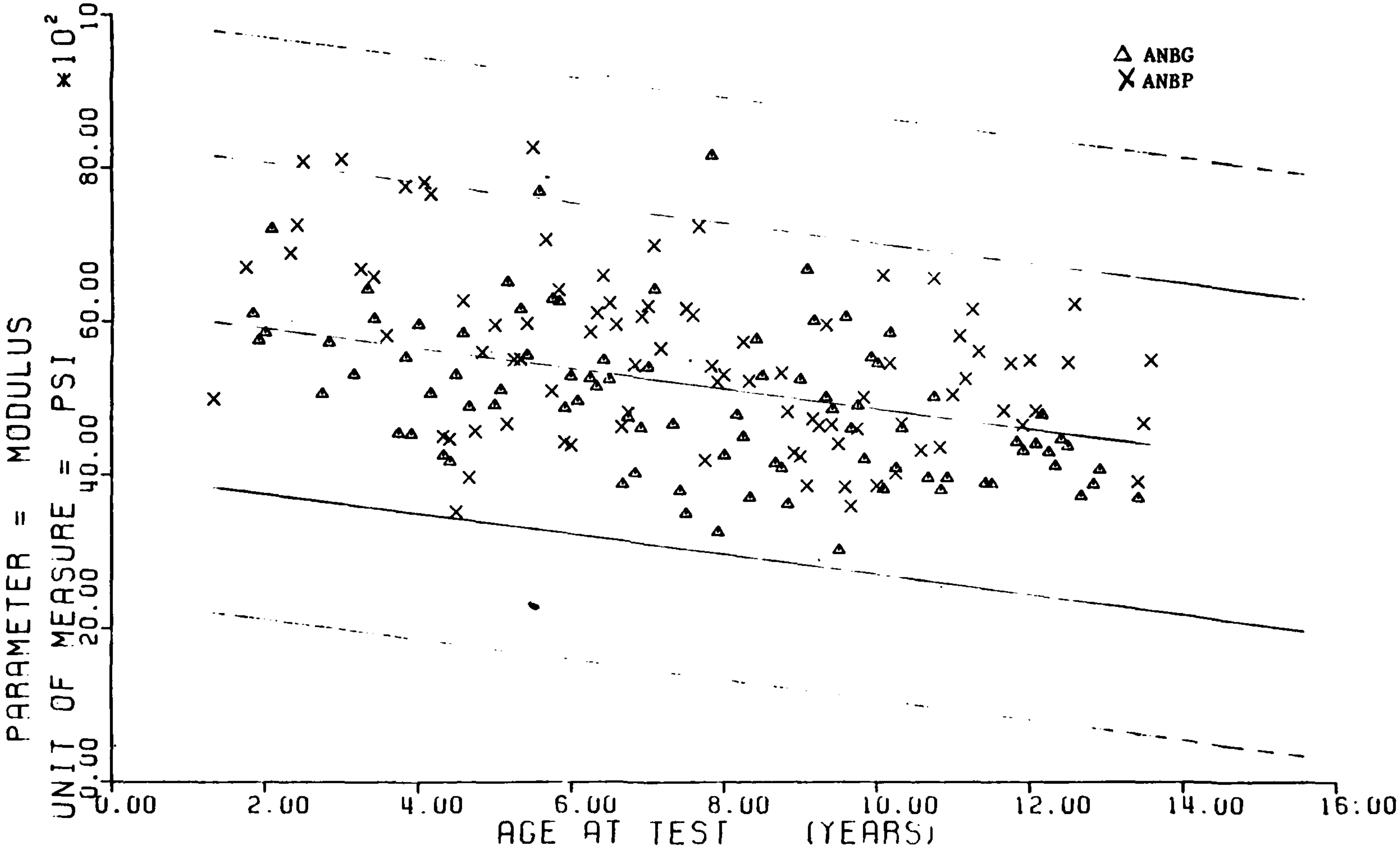
F = +6.6518861E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.3203158E+03

R = -2.9063098E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.3403899E+00

t = +8.1559095E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.2642004E+03

N = 723 DEGREES OF FREEDOM = 721

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



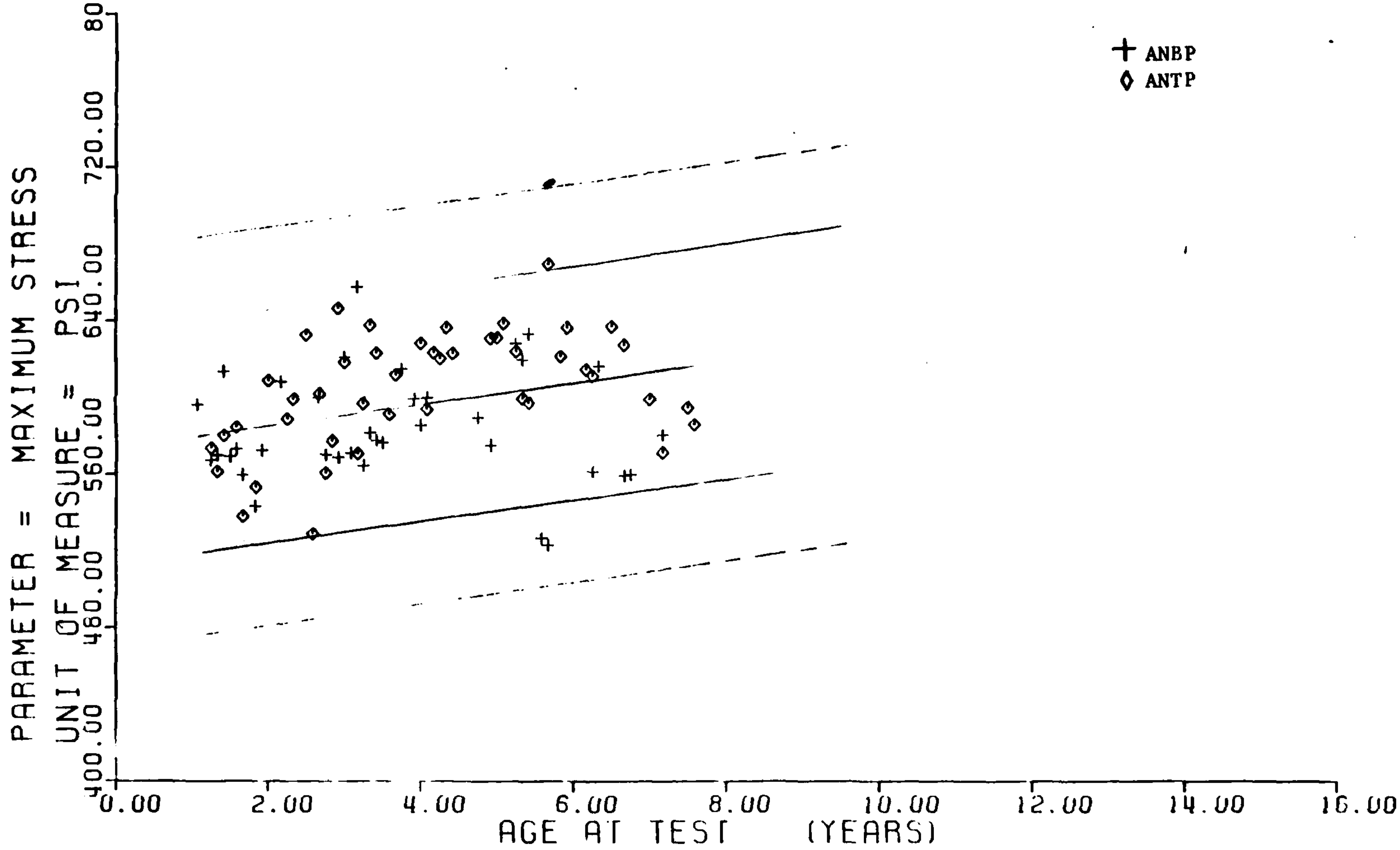
TENSILE TRIAXIAL MODULUS, ANB-3066 (ANB G & P POLY UNLINED), 1750 IN/M, 600 PSI

Figure 5-9

$Y = ((+5.7345627E+02) + (+4.0798318E-01) \times X)$

F = +1.9325899E+01	SIGNIFICANCE OF F = SIGNIFICANT	σ_Y = +3.5778641E+01
R = +2.6688503E-01	SIGNIFICANCE OF R = SIGNIFICANT	S_b = +1.0645361E-01
t = +4.3961231E+00	SIGNIFICANCE OF t = SIGNIFICANT	S_ε = +3.4549238E+01
N = 254	DEGREES OF FREEDOM = 252	

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE TRIAX MAX STRESS, 9NB-3066 (ANT & ANB P-POLY LINED), 1750 IN/M, 600 PSI

Figure 5-10

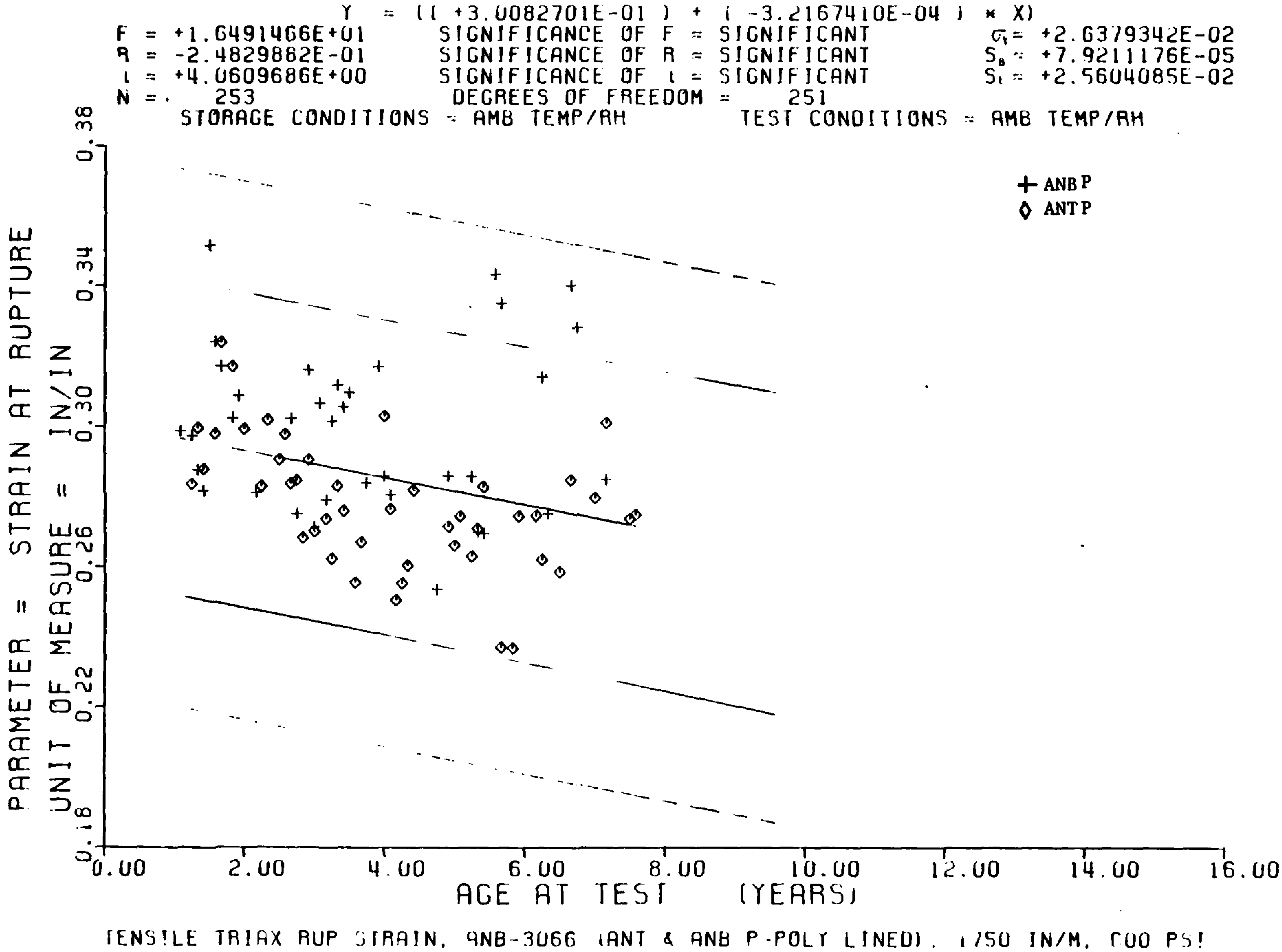

Y = ((+3.0082701E-01) + (-3.2167410E-04) * X)
F = +1.6491466E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +2.6379342E-02
R = -2.4829882E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +7.9211176E-05
t = +4.0609686E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +2.5604085E-02
N = 253 DEGREES OF FREEDOM = 251
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
+ ANBP
◊ ANTP
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.38
0.34
0.30
0.26
0.22
0.18
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TENSILE TRIAX RUP STRAIN, ANB-3066 (ANT & ANB P-POLY LINED), .750 IN/M, 000 PSI

Figure 5-11

Y = ((+3.8579087E+03) + (+1.0181296E+01) × X)

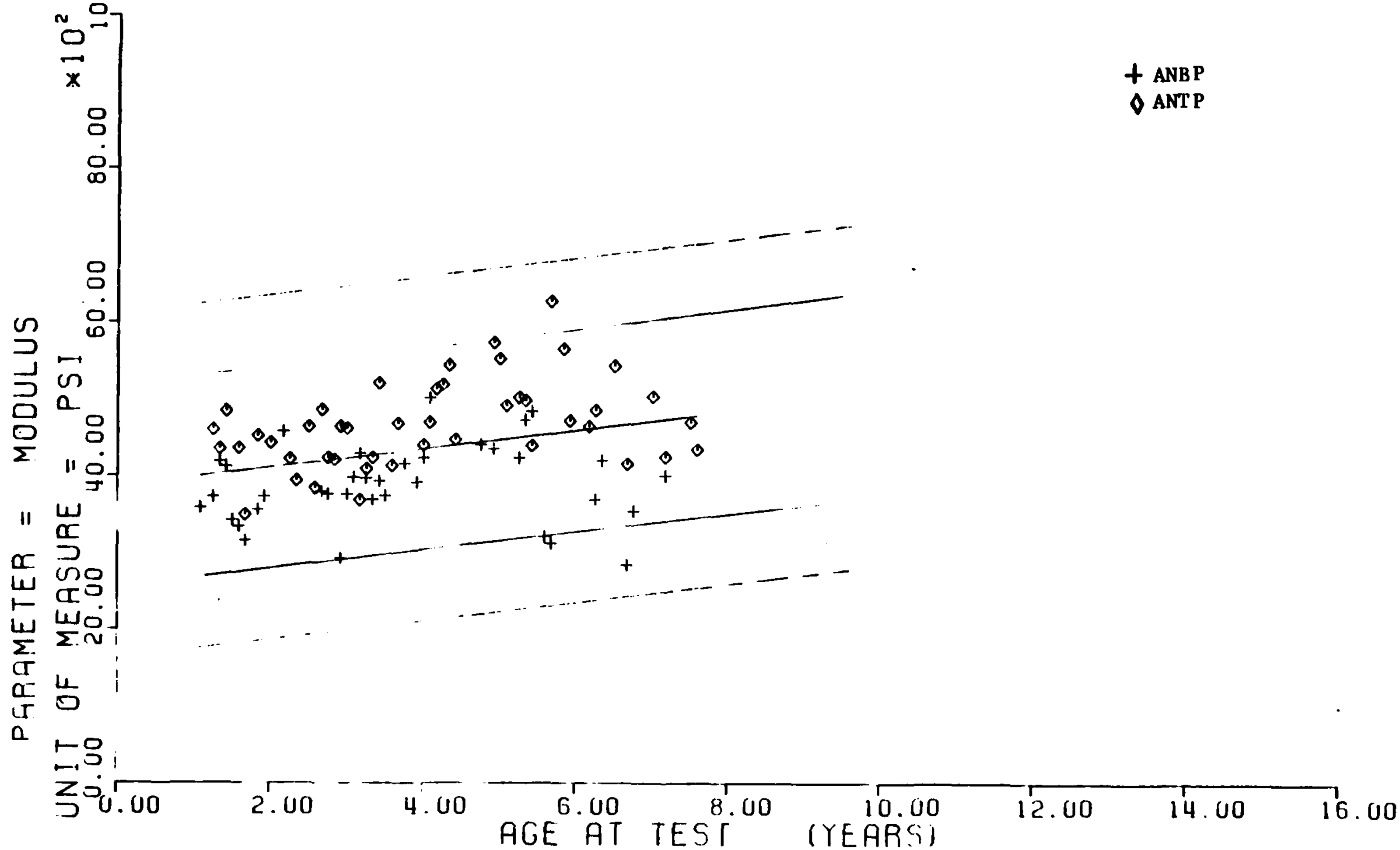
F = +1.9576441E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +7.7374900E+02

R = +2.6848549E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.3011039E+00

t = +4.4245272E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +7.4681721E+02

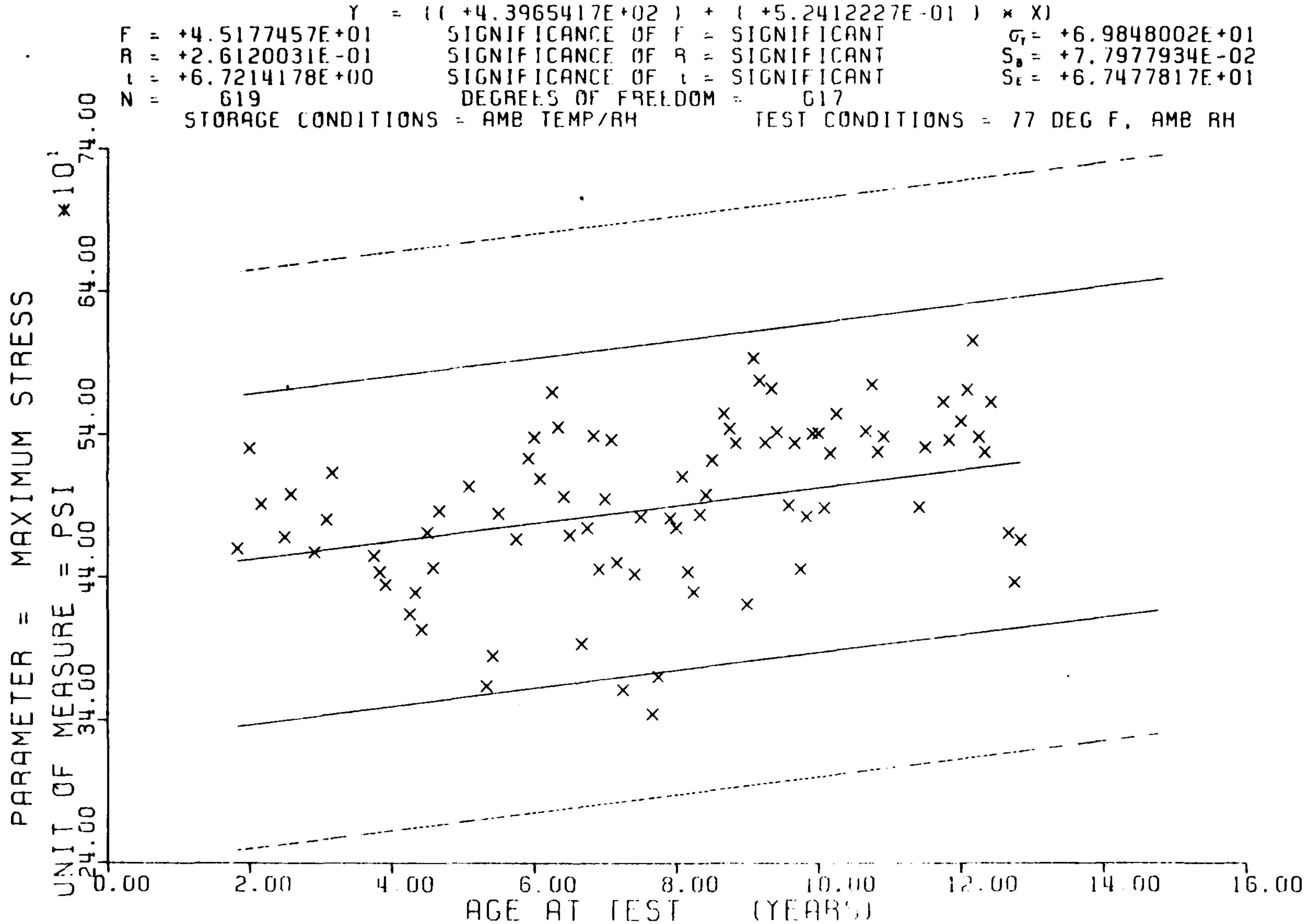
N = 254 DEGREES OF FREEDOM = 252

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



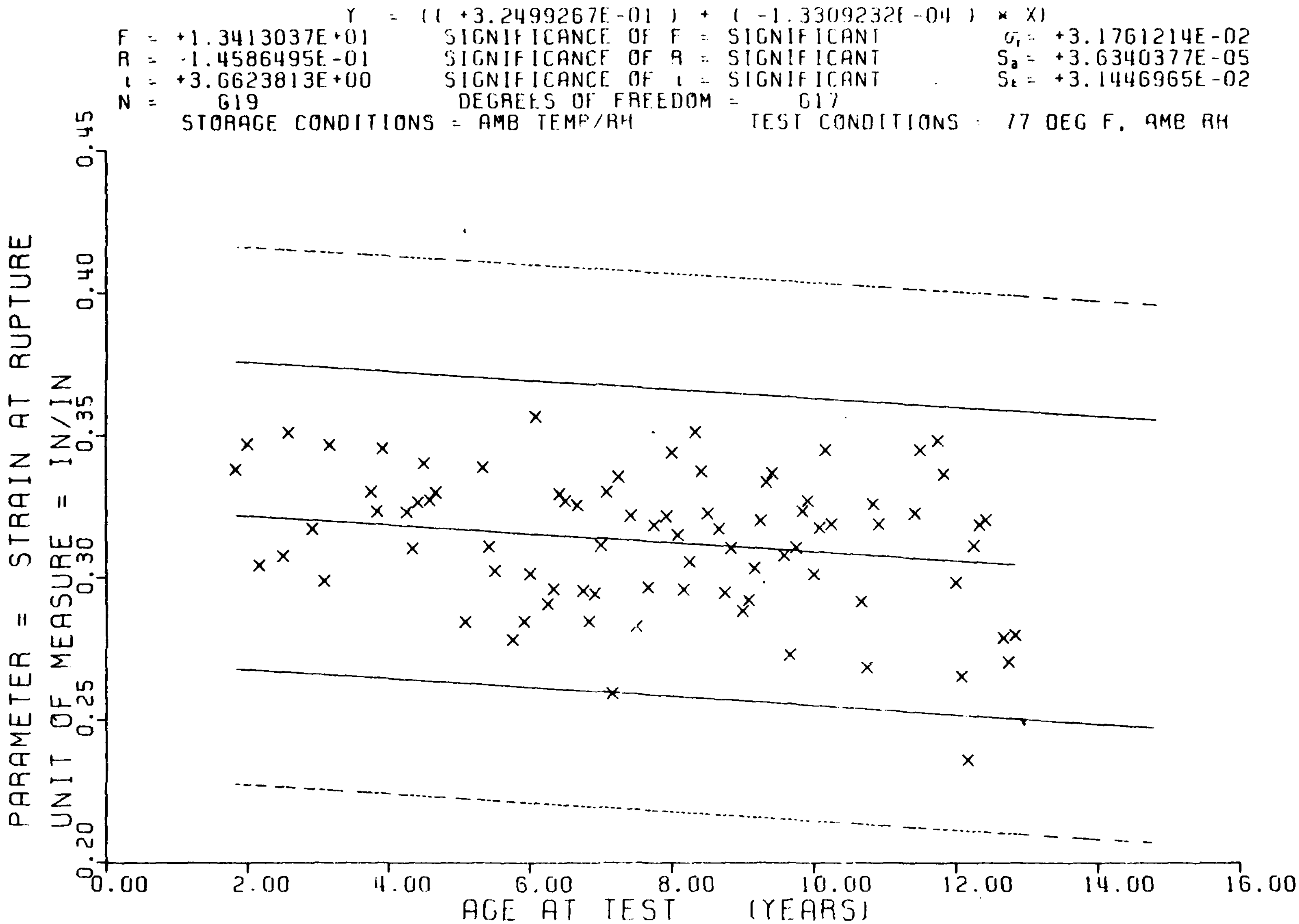
TENSILE TRIAXIAL MODULUS, ANB-3066 (ANT & ANB P-POLY LINED), 1750 IN/M, 600 PSI

Figure 5-12



TENSILE MAXIMUM STRESS, ANB-3066 (ANP G-POLY UNLND), 1/50 IN/MIN, 600 PSI

Figure 5-13



TENSILE RUPTURE STRAIN, ANB-3066 (ANB G-POLY UNLND), 1750 IN/MIN, 600 PSI

Figure 5-14

Y = ((+2.4531359E+03) + (+1.3301552E+01) * X)

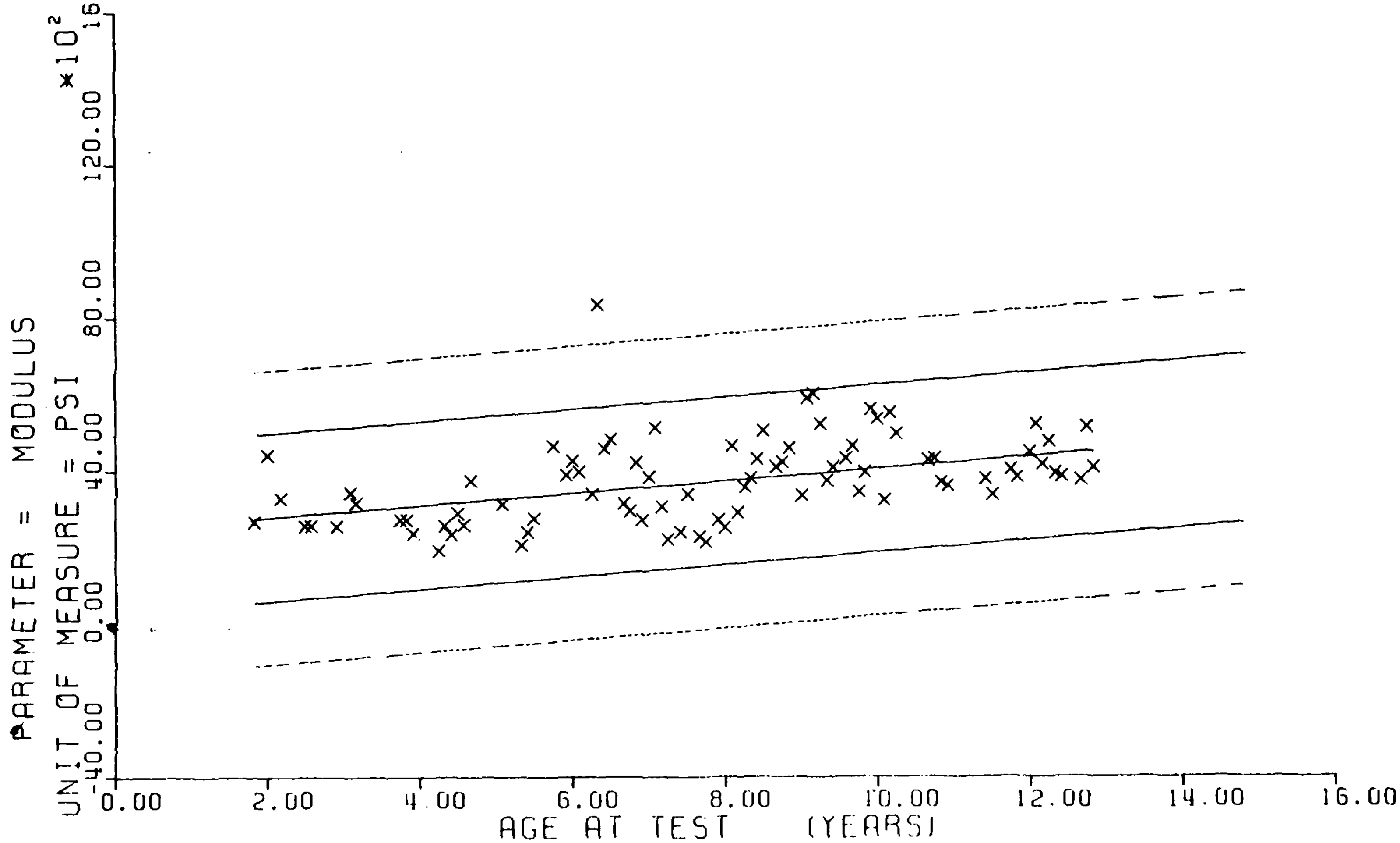
F = +8.0642116E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.3618609E+03

R = +3.3998880E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.4812261E+00

t = +8.9800955E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.2817716E+03

N = 619 DEGREES OF FREEDOM = 617

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE MODULUS, ANB-3066 (ANB G-POLY UNLND), 1750 IN/MIN, 600 PSI

Figure 5-15

Y = ((+4.5758896E+02) + (+6.6215801E-01) * X)

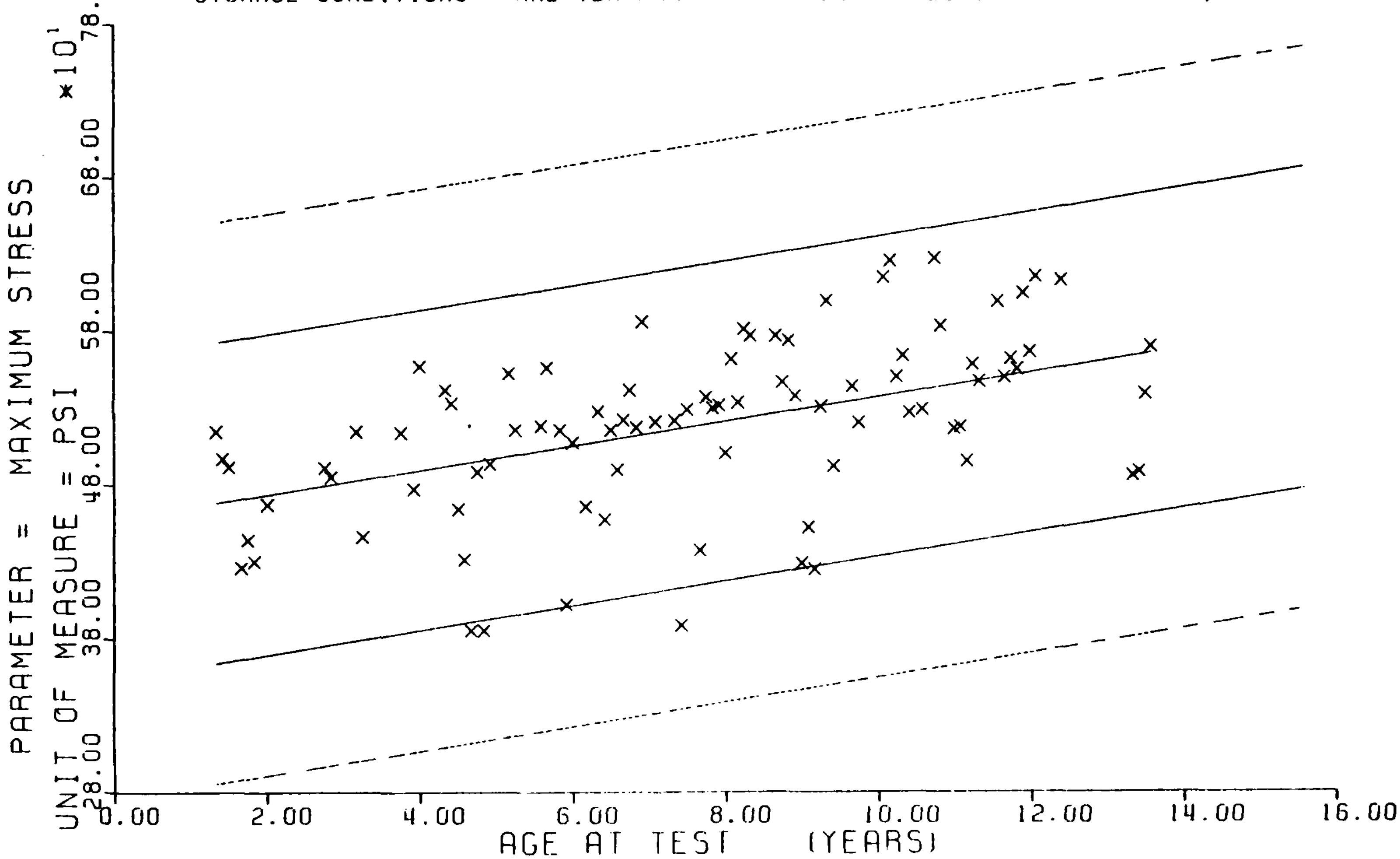
F = +1.1077415E+02 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +6.6043335E+01

R = +3.8748733E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +6.2913291E-02

t = +1.0524930E+01 SIGNIFICANCE OF t = SIGNIFICANT S_E = +6.0932233E+01

N = 629 DEGREES OF FREEDOM = 627

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



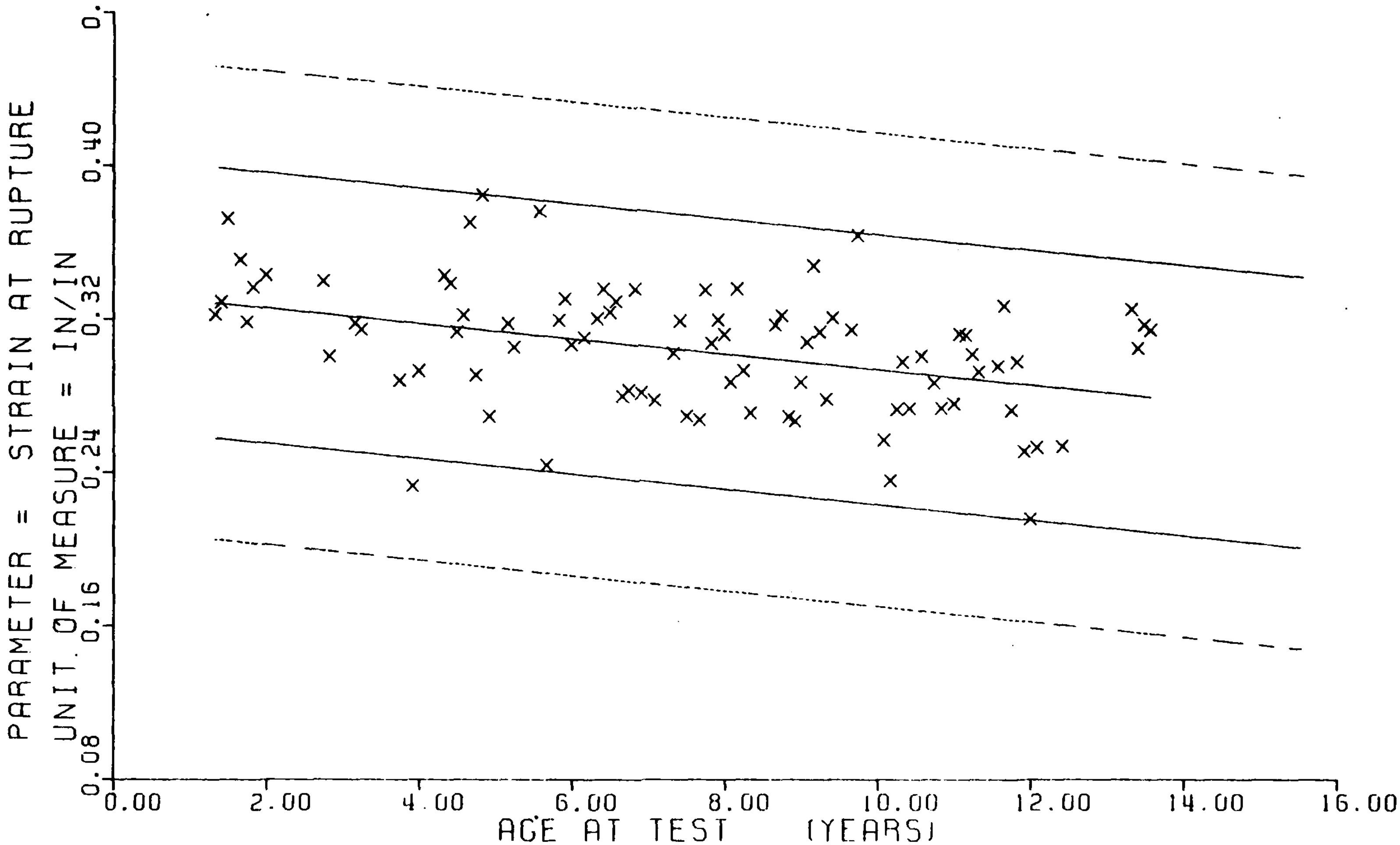
TENSILE MAXIMUM STRESS, ANB-3066 (ANB P-POLY UNLND), 1750 IN/MIN, 600 PSI

Figure 5-16

Y = ((+3.3377563E-01) + (-3.3564421E-04) * X)

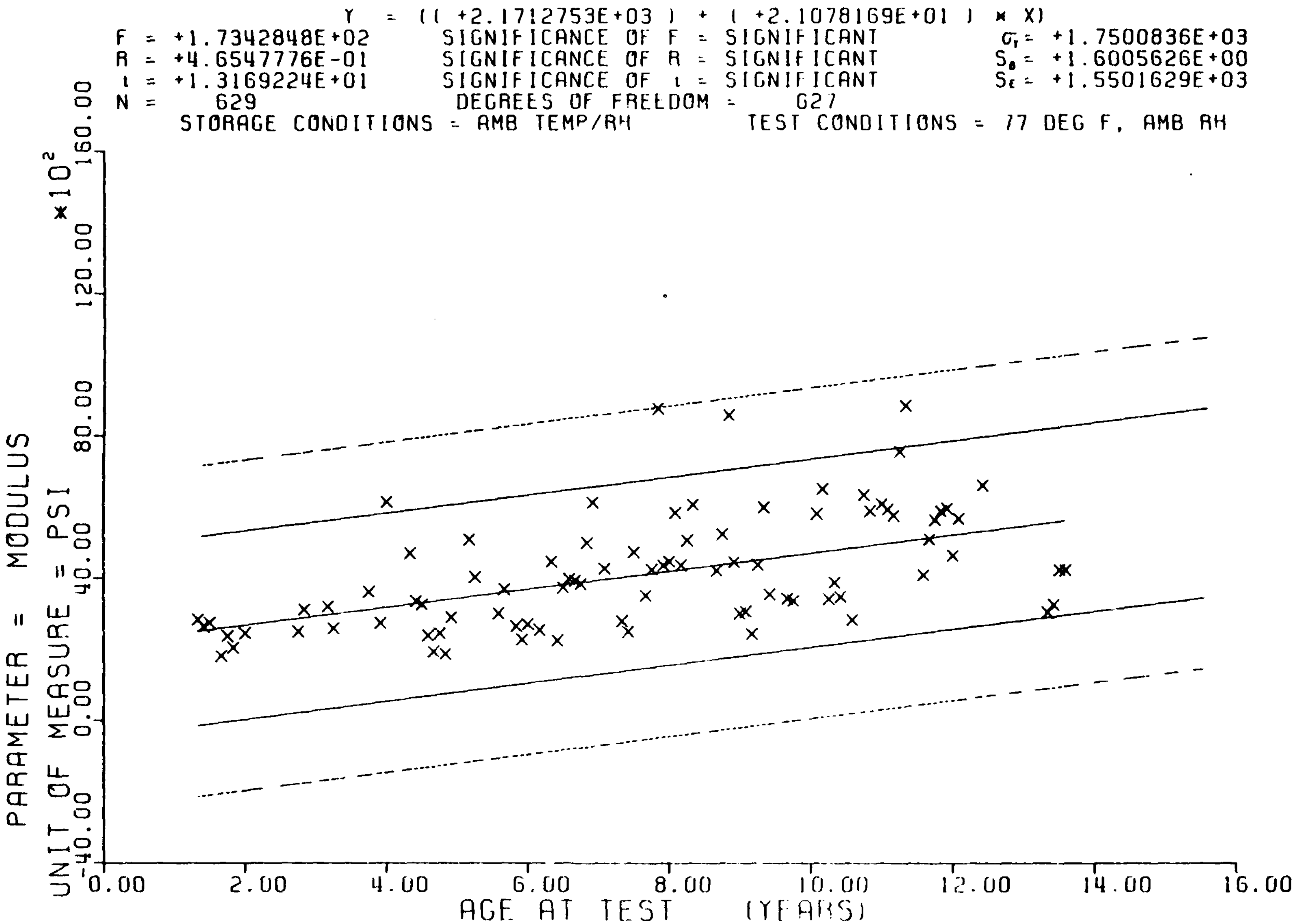
F = +6.2631675E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +4.3044297E-02
R = -3.0136194E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +4.2411355E-05
t = +7.9140176E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +4.1075877E-02
N = 629 DEGREES OF FREEDOM = 627

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE RUPTURE STRAIN, ANB-3066 (ANB P-POLY UNLND), 1750 IN/MIN, 600 PSI

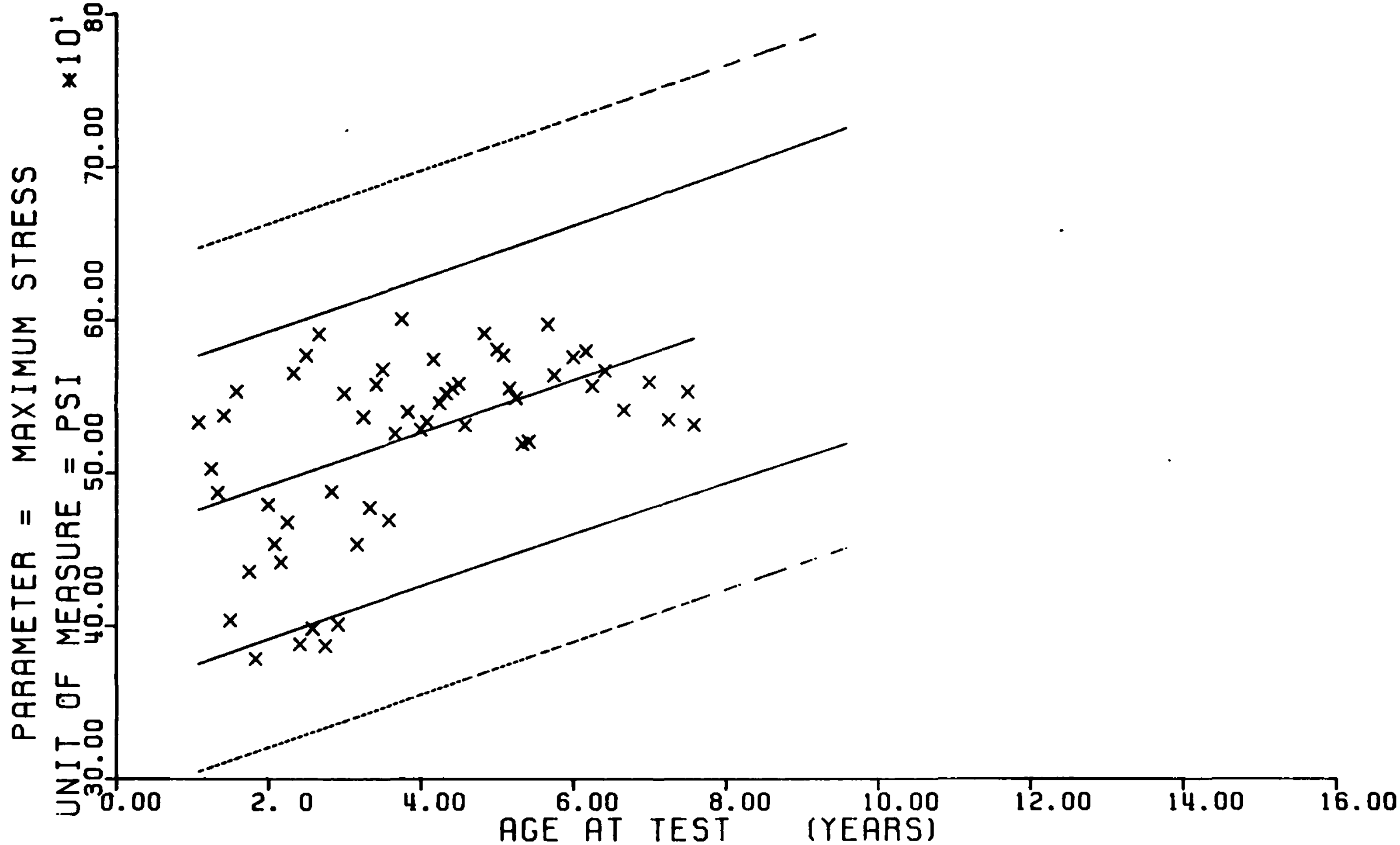
Figure 5-17



TENSILE MODULUS, ANB-3066 (ANB P-POLY UNLND), 1750 IN/MIN, 600 PSI

Figure 5-18

Y = ((+4.5718398E+02) + (+1.4335450E+00) * X)
F = +5.6261734 +01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +6.3600186E+01
R = +4.4566918E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.9111940 -01
t = +7 5 07822E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +5.706 011E+01
N = 229 DEGREES OF F EEDOM = 227
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



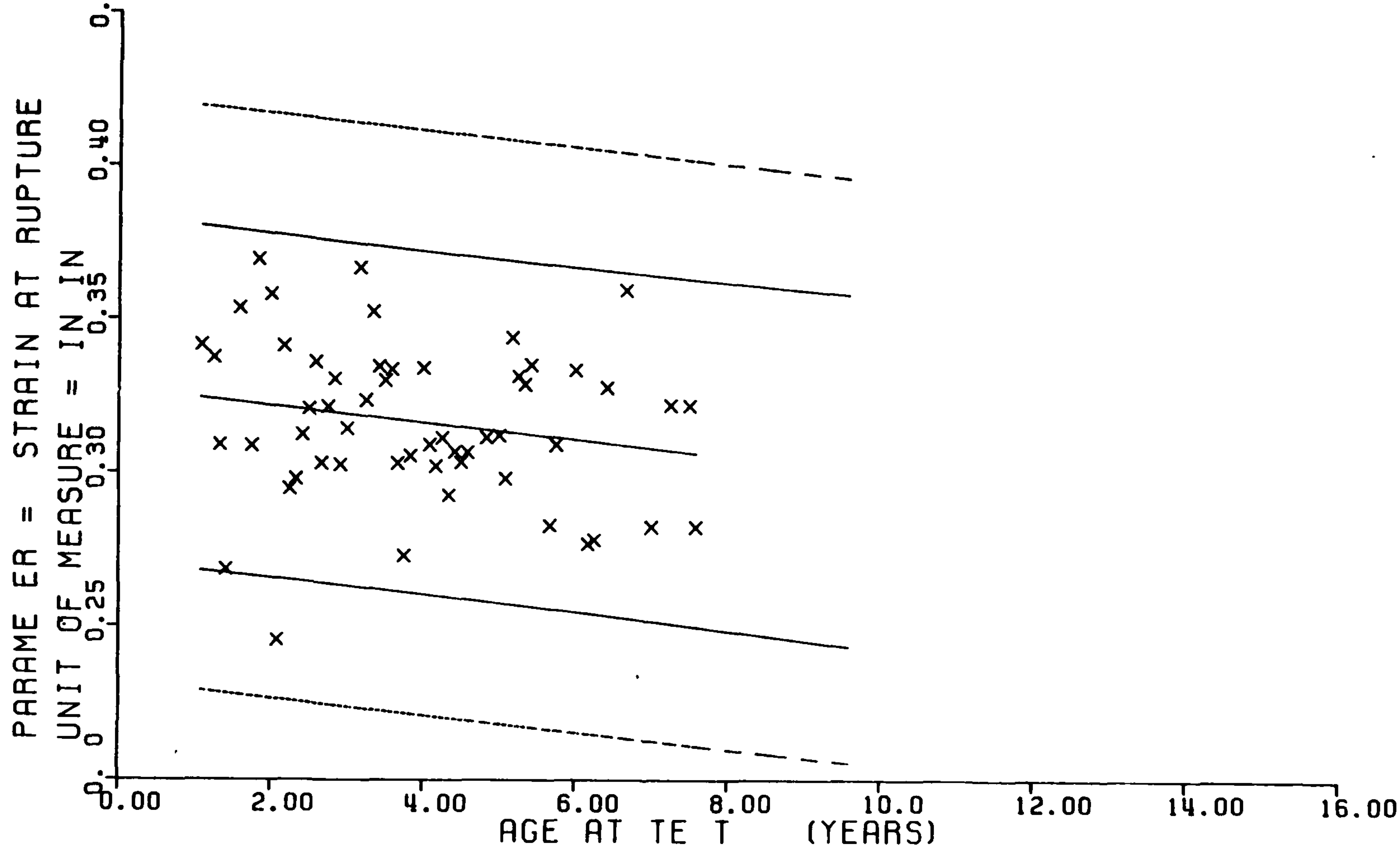
TENSILE MAXIMUM STRESS, ANB-3066 (ANT P-POLY LINED), 1750 IN/MIN, 600 PSI

Figure 5-19

Y = ((+3.2718549E-01) + (-2.3020500E-04) * X)

F = +4.6940213E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +3.1978589E-02
R = -1.4233611E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.0625325E-04
ι = +2.1665690E+00 SIGNIFICANCE OF ι = SIGNI ICANT S_E = +3.1722638E-02
N = 229 DEGREES OF FREEDOM = 227

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



TENSILE RUPTURE STRAIN, ANB-3066 (ANT P-POLY LINED), 1750 IN/MIN, 600 PSI

Figure 5-20

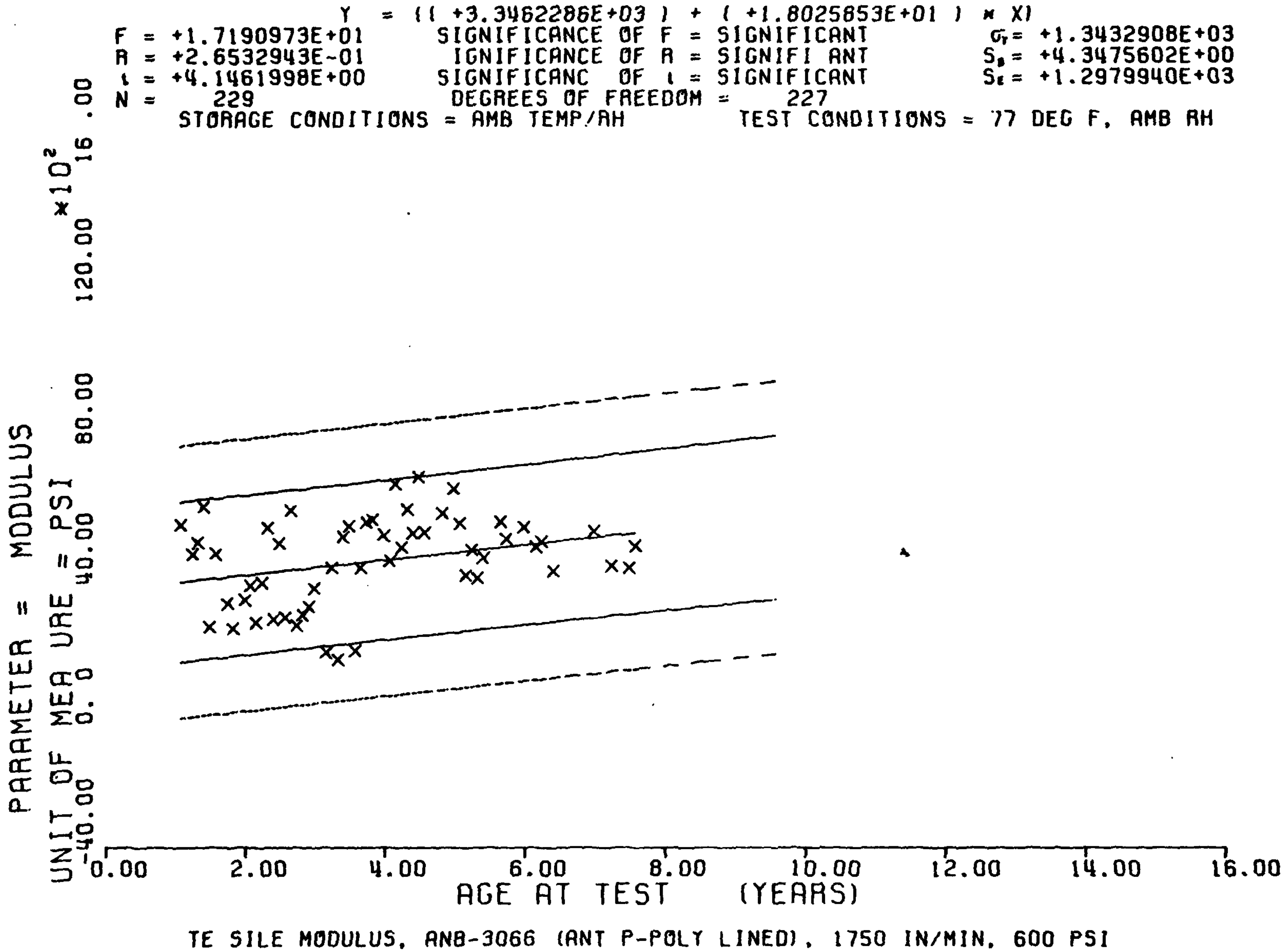

Y = ((+3.3462286E+03) + (+1.8025853E+01) * X)
F = +1.7190973E+01 SIGNIFICANCE OF F = SIGNIFICANT σ = +1.3432908E+03
R = +2.6532943E-01 IGNIFICANCE OF R = SIGNIFI ANT S = +4.3475602E+00
ι = +4.1461998E+00 SIGNIFICANC OF ι = SIGNIFICANT S = +1.2979940E+03
N = 229 DEGREES OF FREEDOM = 227
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = MODULUS
UNIT OF MEA URE = PSI
×10²
-40.00
0.0
40.00
80.00
120.00
16 .00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
TE SILE MODULUS, ANB-3066 (ANT P-POLY LINED), 1750 IN/MIN, 600 PSI

Figure 5-21

SECTION VI

STRESS RELAXATION AND STRAIN DILATION

A. STRESS RELAXATION:

An end bonded 1/2" x 1/2" x 4" specimen (1.27 x 1.27 x 10.16 cm) is tested on the stress relaxometer. Load is applied at 2 in/min (.085 cm/sec). Timing begins when the load is applied. Specimens have been strained at both 1% and 3%.

The use of 1% strain over the range of temperatures was not introduced into the program until Phase 3 of Minuteman III testing and Phase B Series 2 for Minuteman II. In this report, data for both 1% and 3% at 77°F are shown for a comparison between applied strains. Thiokol has shown that strains introduced into the propellant during machining remain in the samples and a higher strain is required to give reproducible and accurate relaxation moduli. The 1% strain is considered to be very marginal insofar as reproducible data is concerned.

Table 6-1 gives the significance of 't' for both 1% and 3% strains. The number of specimens represented in each regression is shown so that the preponderance of test data at 3% strain is obvious. Next report will show composite regressions of 3% data.

Unlined cartons of ANB "G" show a significant decrease for both 1% and 3% (154 mo) while there is no significant change for lined cartons (82 mo).

Unlined cartons of ANB "P" show a significant increase at 1% (86 mo), but the 1000 second modulus at 3% shows a significant increase.

Unlined cartons of ANT "P" do not show a significant decrease at 1% (81), but the decrease is significant at 3% (91). Lined cartons (80 mo) still show a significant increase.

These data tend to contradict ASPC's findings which suggests that samples prepared from cartons appeared to decrease in modulus after 3.5 to 4 years of storage (ASPC 0162-06SAAS-21).

Gradient stress relaxation does not show a change from the last report. Minima occurs at approximately 2.2 inches from the liner.

B. STRAIN DILATATION:

The same type of specimen is used for this test as for stress relaxation. Testing is done in a gas dilatometer at 77°F (25°C) without pressure.

Poisson's Ratio at 15% strain consistently shows a significant decrease (Table 6-2). At maximum strain, Poisson's ratio is significantly decreasing for unlined cartons. ANB "G" and "P" unlined cartons do not show a significant change, while other cartons show a significant decrease.

TABLE 6-1
STRESS RELAXATION

Significance of Regression Slopes

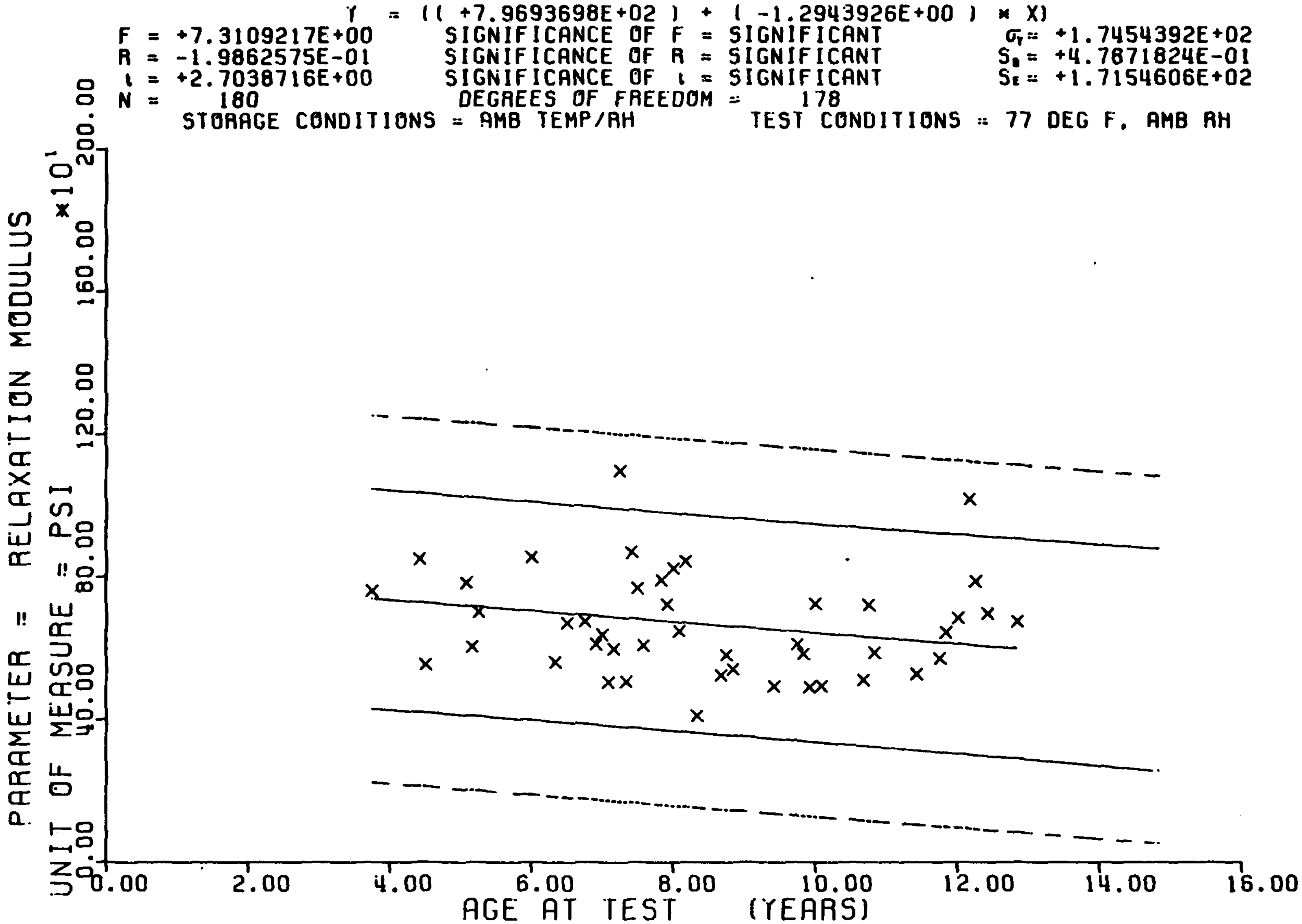
SYSTEM	N	10 sec 1%	N	10 sec 3%	1000 sec 1%	1000 sec 3%
ANB G Unlined	180	Sig dec	760	Sig dec	Sig dec	Sig dec
ANB G Lined	48	NS	112	NS	NS	Sig inc
ANB P Unlined	168	Sig inc	589	Sig inc	Sig inc	Sig inc
ANB P Lined	72	NS	158	Sig inc	NS	Sig inc
ANT P Unlined	156	NS	399	Sig dec	NS	Sig dec
ANT P Lined	144	Sig inc	309	Sig dec	Sig inc	Sig inc
ANA & ANB G	218	Sig dec			Sig dec	
ANB G & P Unlined	348	Sig inc			NS	
ANB G & P Lined	120	NS			NS	
ANB & ANT P Unlined	324	Sig inc			Sig inc	
ANB & ANT P Lined	216	Sig inc			Sig inc	

TABLE 6-2
DILATATION

Significance of Regression Slopes

SYSTEM	POISSONS RATIO AT 15% STRAIN	POISSONS RATIO AT MAX STRAIN	DILATATION AT MAX STRAIN
ANB G Unlined	Sig dec	Sig dec	NS
ANB G Lined	Sig dec	NS	Sig dec
ANB P Unlined	Sig dec	Sig dec	NS
ANB P Lined	Sig dec	NS	Sig dec
ANT P Unlined	Sig dec	Sig dec	Sig dec
ANT P Lined	Sig dec	NS	Sig dec

NS = Not significantly different from zero slope
Sig inc = Positive slope
Sig dec = Negative slope

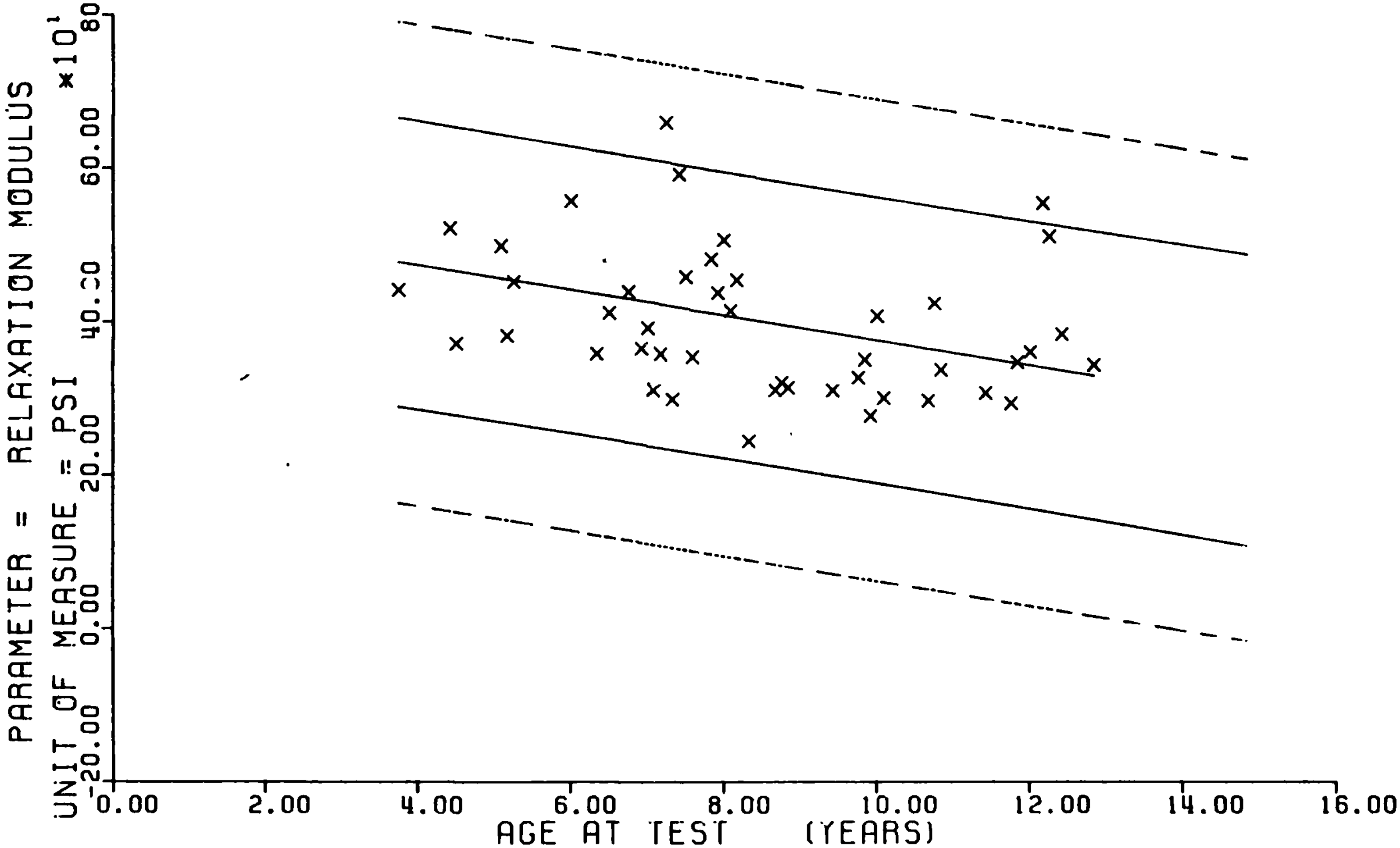


STRESS RELAXATION MODULUS, ANB-3066 (ANB G-POLYMER UNLND), 10 SEC, 1% STRAIN

Figure 6-1

Y = ((+5.3700450E+02) + (-1.3510545E+00) * X)

F = +2.1507496E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.1021274E+02
R = -3.2833359E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.9132513E-01
t = +4.6376175E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.0439476E+02
N = 180 DEGREES OF FREEDOM = 178
STORAGE CONDITIONS = AMB TEMP/RH TEST CO DITIONS = 77 DEG F, AMB RH



STRESS RELAXATION MODULUS, ANB-3066 (ANB G-POLYMER UNLND), 1000 SEC, 1% STRAIN

Figure 6-2

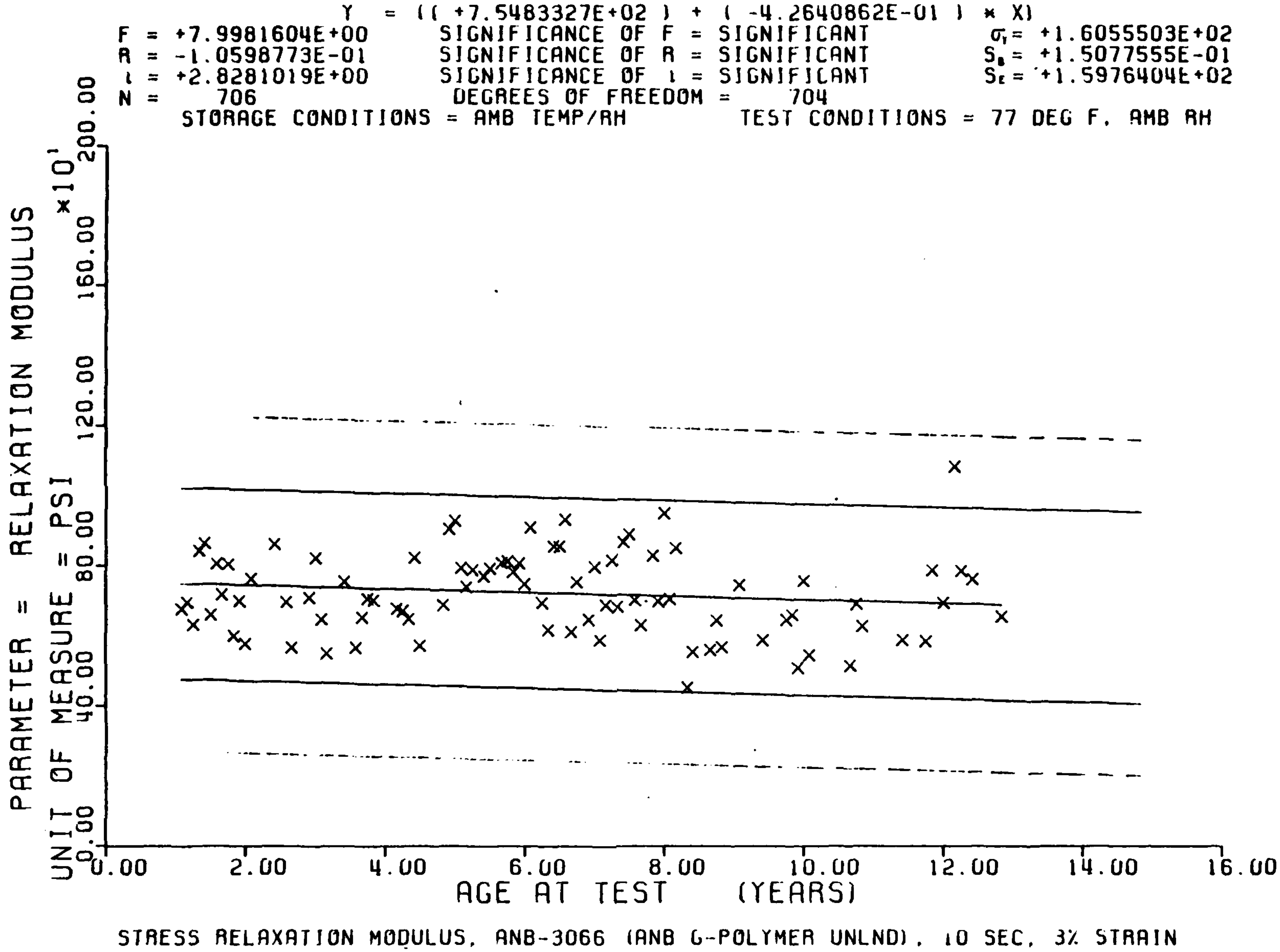

Y = ((+7.5483327E+02) + (-4.2640862E-01) * X)
F = +7.9981604E+00 SIGNIFICANCE OF F = SIGNIFICANT σT = +1.6055503E+02
R = -1.0598773E-01 SIGNIFICANCE OF R = SIGNIFICANT SB = +1.5077555E-01
ι = +2.8281019E+00 SIGNIFICANCE OF ι = SIGNIFICANT SE = +1.5976404E+02
N = 706 DEGREES OF FREEDOM = 704
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI ×10¹
0.00
40.00
80.00
120.00
160.00
200.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
STRESS RELAXATION MODULUS, ANB-3066 (ANB G-POLYMER UNLND), 10 SEC, 3% STRAIN

Figure 6-3

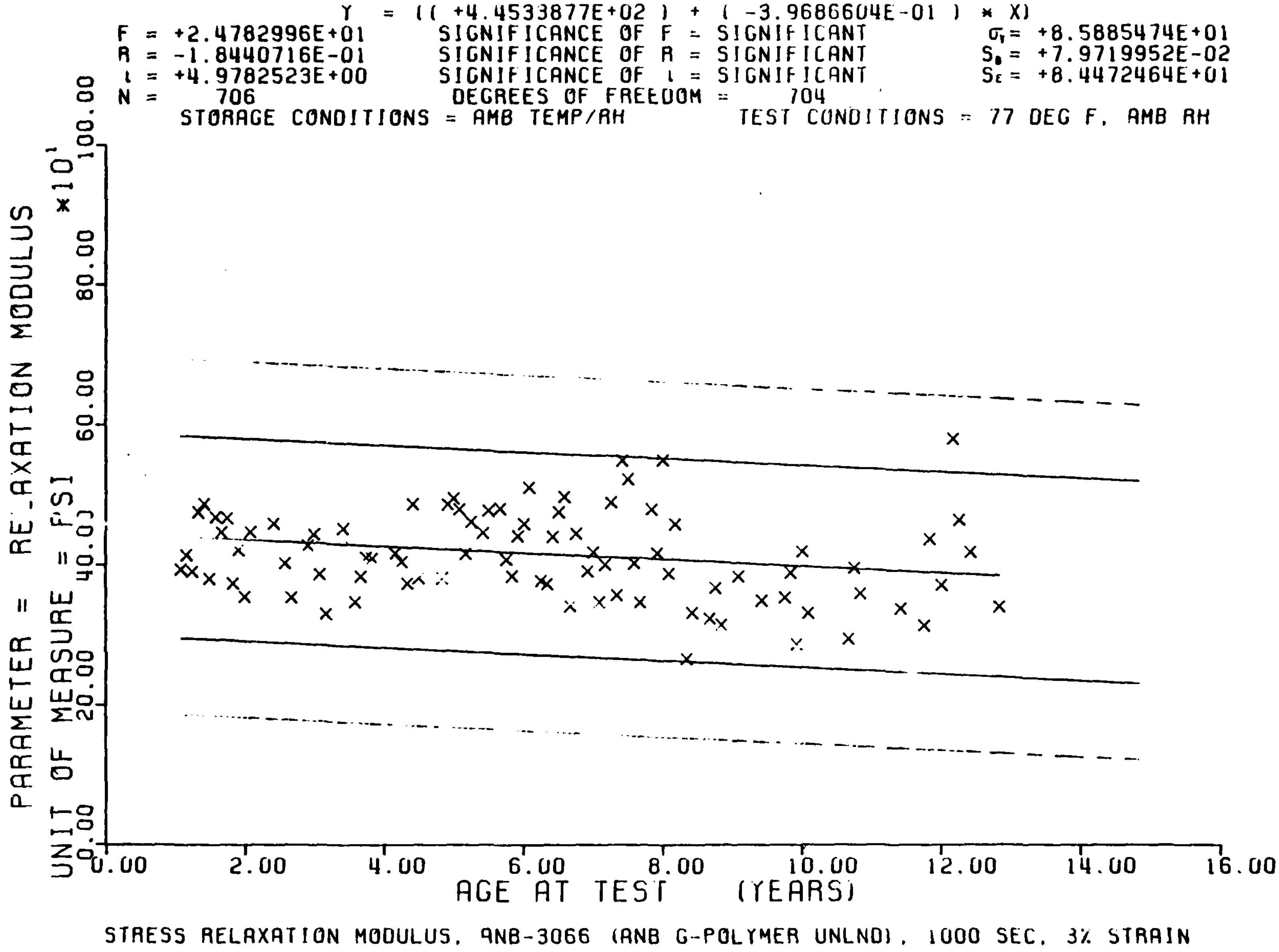
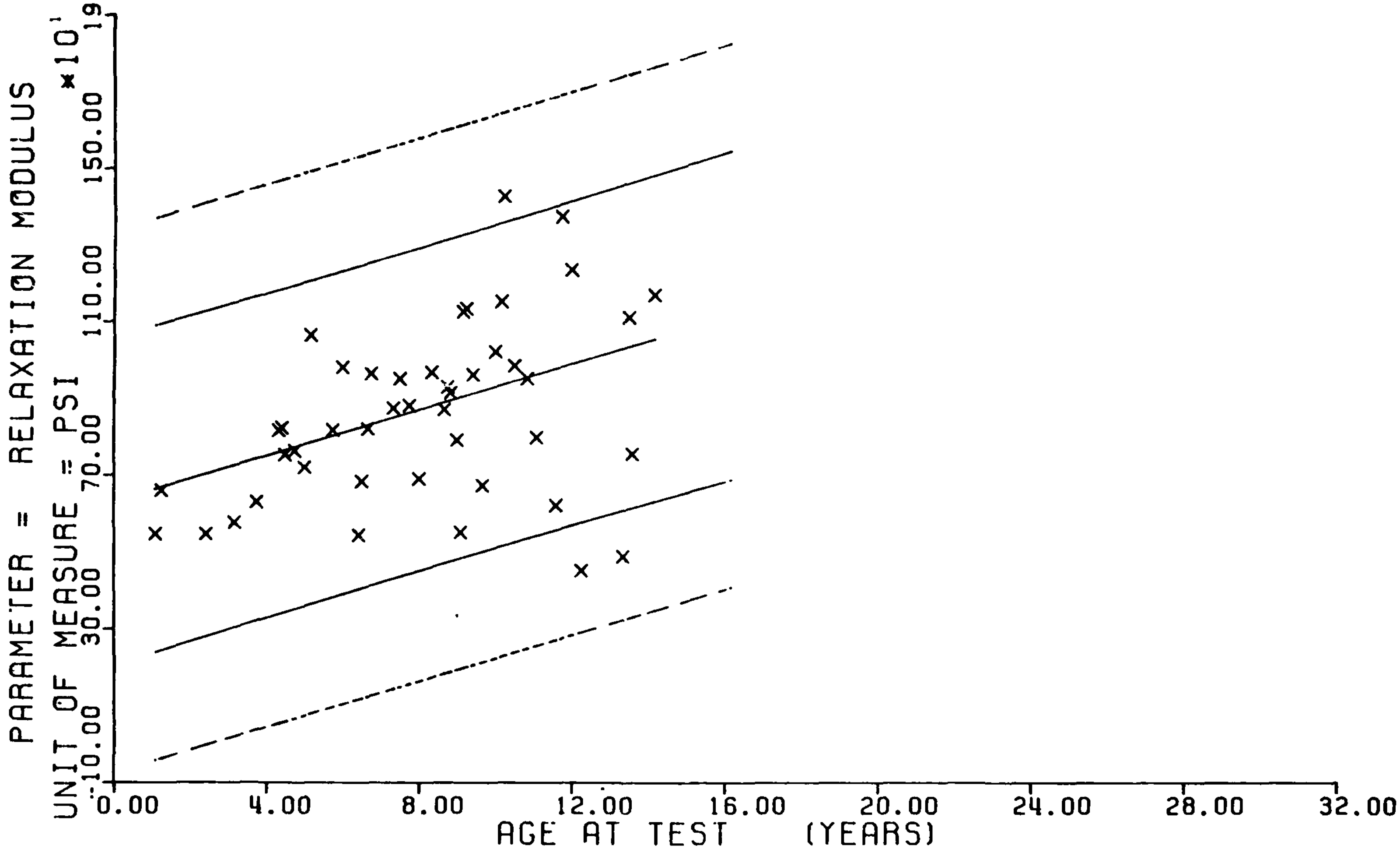

Y = ((+4.4533877E+02) + (-3.9686604E-01) * X)
F = +2.4782996E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +8.5885474E+01
R = -1.8440716E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +7.9719952E-02
t = +4.9782523E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +8.4472464E+01
N = 706 DEGREES OF FREEDOM = 704
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI ×10¹
0.00
20.00
40.00
60.00
80.00
100.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
STRESS RELAXATION MODULUS, ANB-3066 (ANB G-POLYMER UNLND), 1000 SEC, 3% STRAIN

Figure 6-4

Y = ((+6.3110886E+02) + (+2.4836118E+00) * X)

F - +2.7423960E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +2.5356008E+02
R = +3.7653899E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +4.7426233E-01
ι = +5.2367891E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +2.3560471E+02
N = 168 DEGREES OF FREEDOM = 166

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER UNLND), 10 SEC, 1% STRAIN

Figure 6-5

Y = ((+4.2137749E+02) + (+8.8670901E-01) * X)

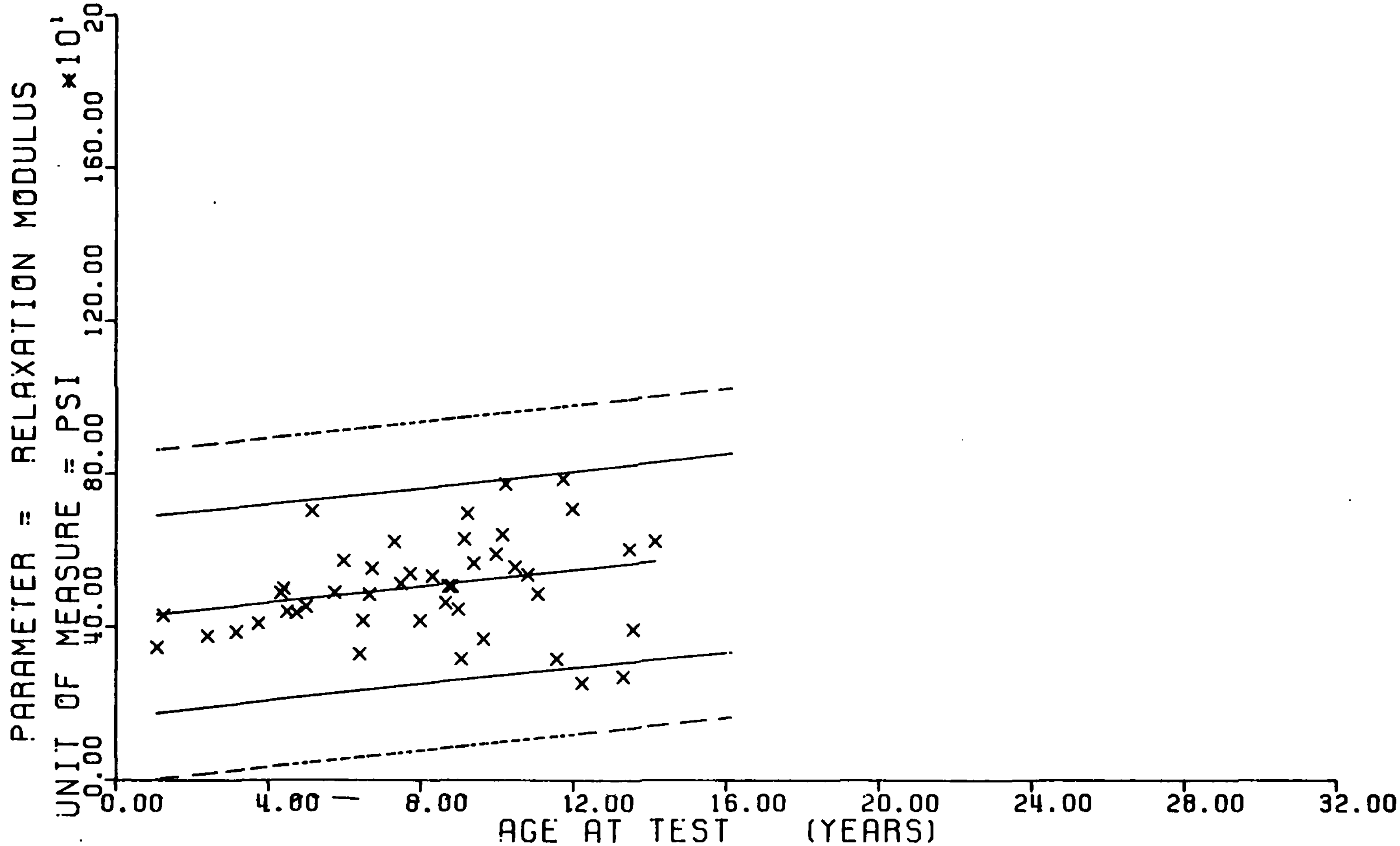
F = +9.4288376E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.4703125E+02

R = +2.3183477E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.8876998E-01

ι = +3.0706412E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +1.4345556E+02

N = 168 DEGREES OF FREEDOM = 166

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER UNLND), 1000 SEC, 1% STRAIN

Figure 6-6

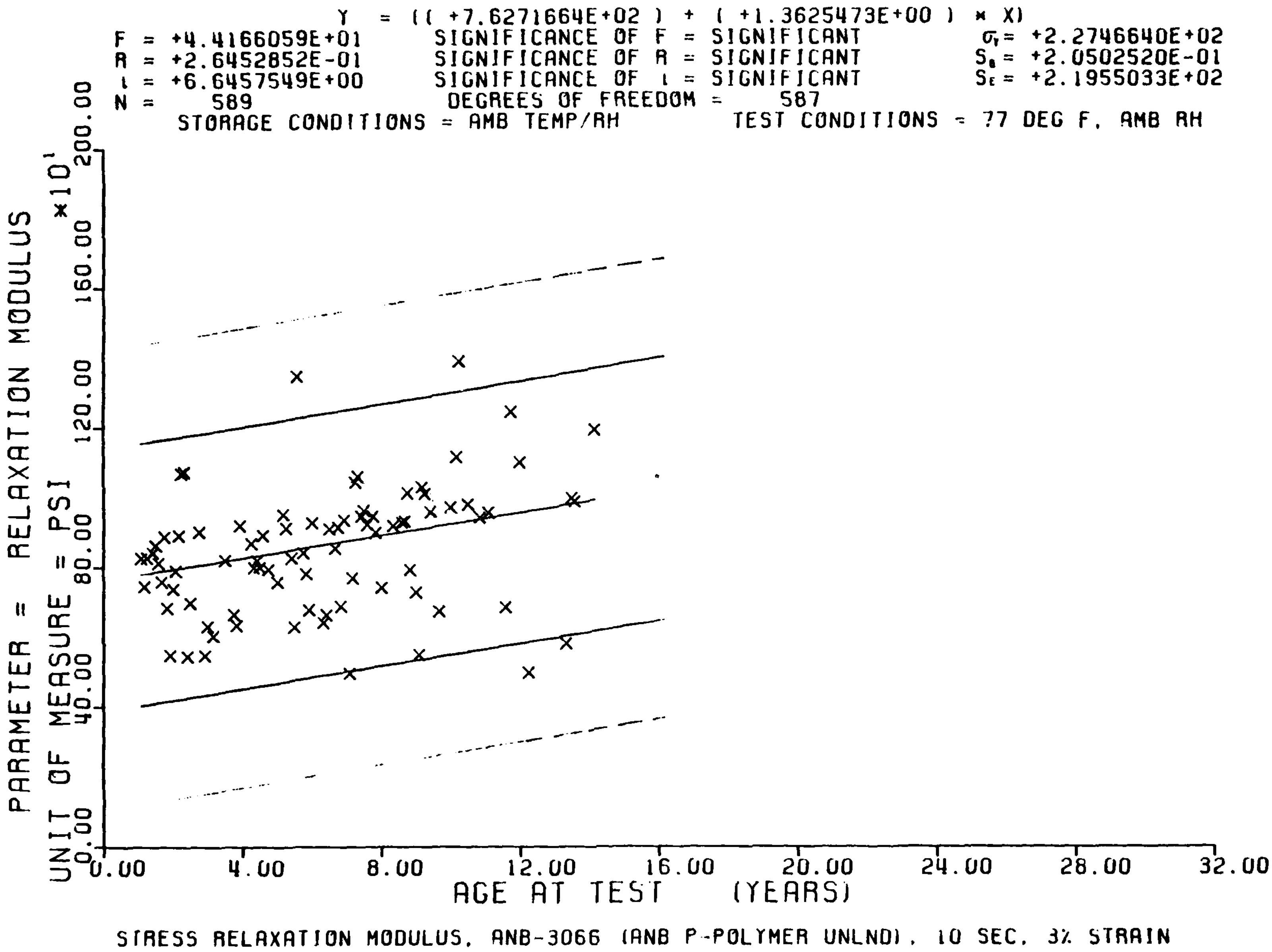
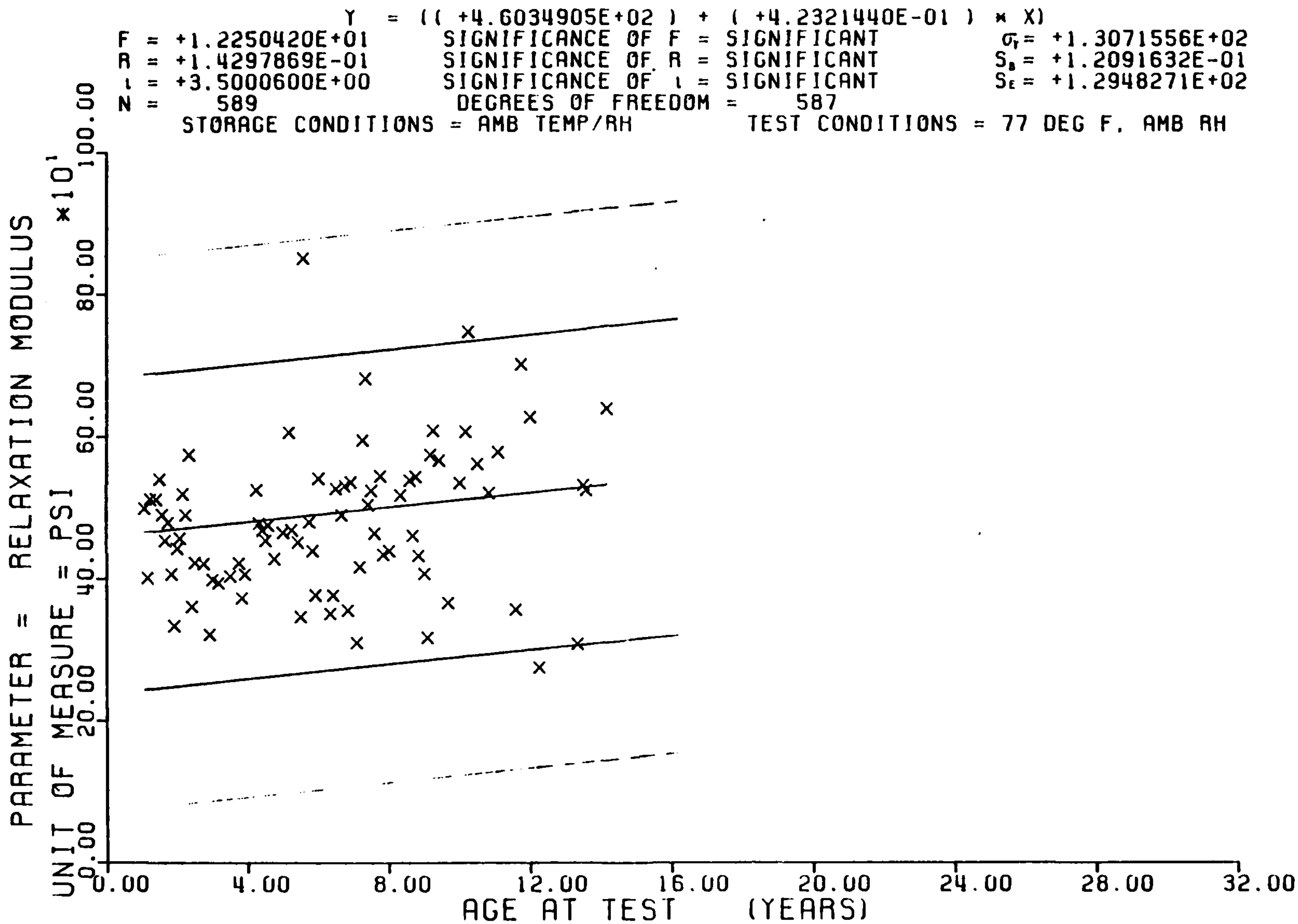

Y = ((+7.6271664E+02) + (+1.3625473E+00) * X)
F = +4.4166059E+01 SIGNIFICANCE OF F = SIGNIFICANT σT = +2.2746640E+02
R = +2.6452852E-01 SIGNIFICANCE OF R = SIGNIFICANT SB = +2.0502520E-01
ι = +6.6457549E+00 SIGNIFICANCE OF ι = SIGNIFICANT SE = +2.1955033E+02
N = 589 DEGREES OF FREEDOM = 587
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI
×10¹
0.00
40.00
80.00
120.00
160.00
200.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER UNLND), 10 SEC, 3% STRAIN

Figure 6-7



STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER UNLND), 1000 SEC, 3% STRAIN

Figure 6-8

Y = ((+6.2802828E+02) + (+1.2270578E+00) * X)

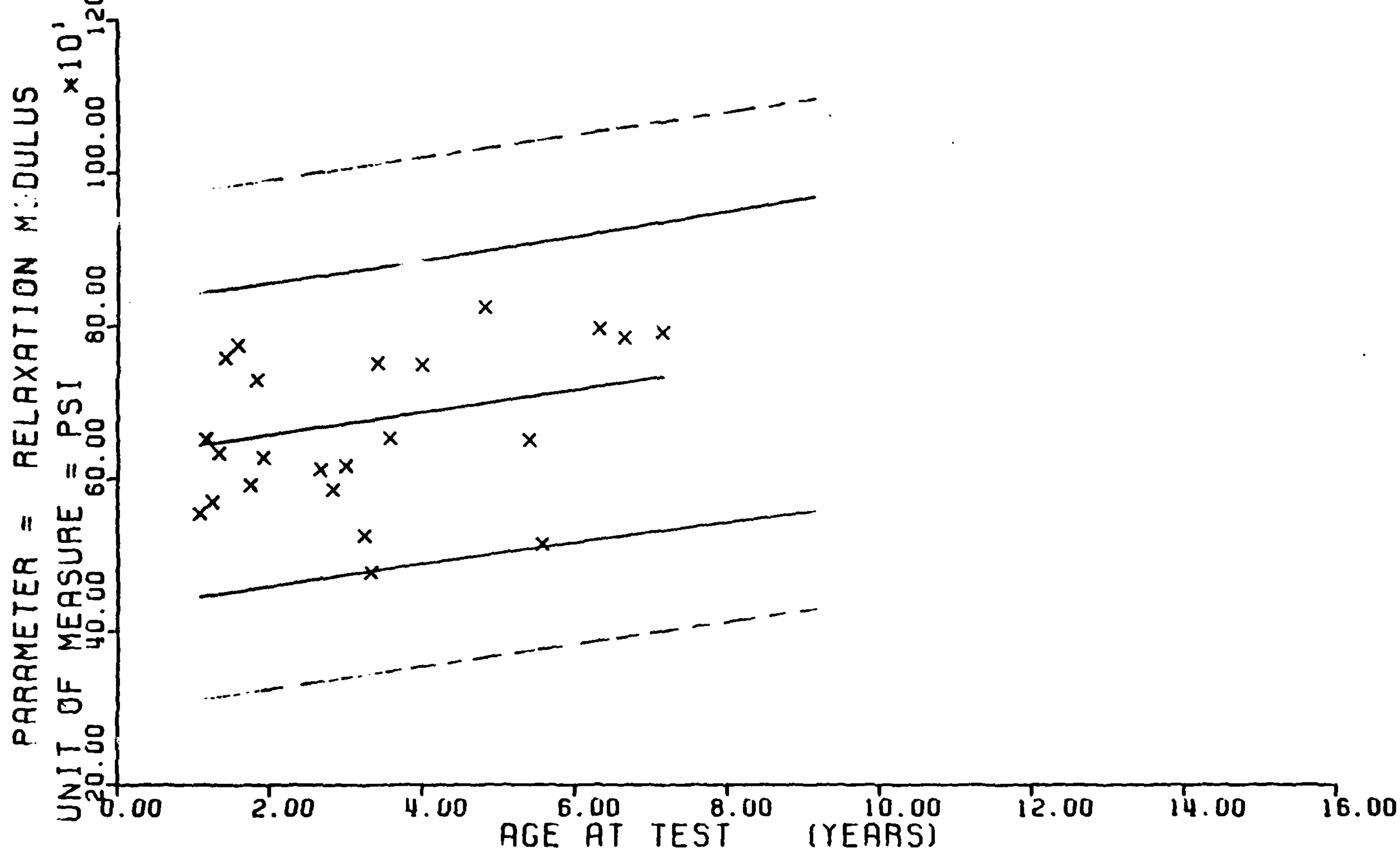
F = +8.7950758E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.1380626E+02

R = +2.3101898E-01 SIGNIFICANCE OF R = SIGNIFICANT S_a = +4.1375690E-01

ι = +2.9656493E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_ε = +1.1108204E+02

N = 158 DEGREES OF FREEDOM = 156

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER LINED), 10 SEC, 3% STRAIN

Figure 6-9

Y = ((+3.6537216E+02) + (+1.0706272E+00) * X)

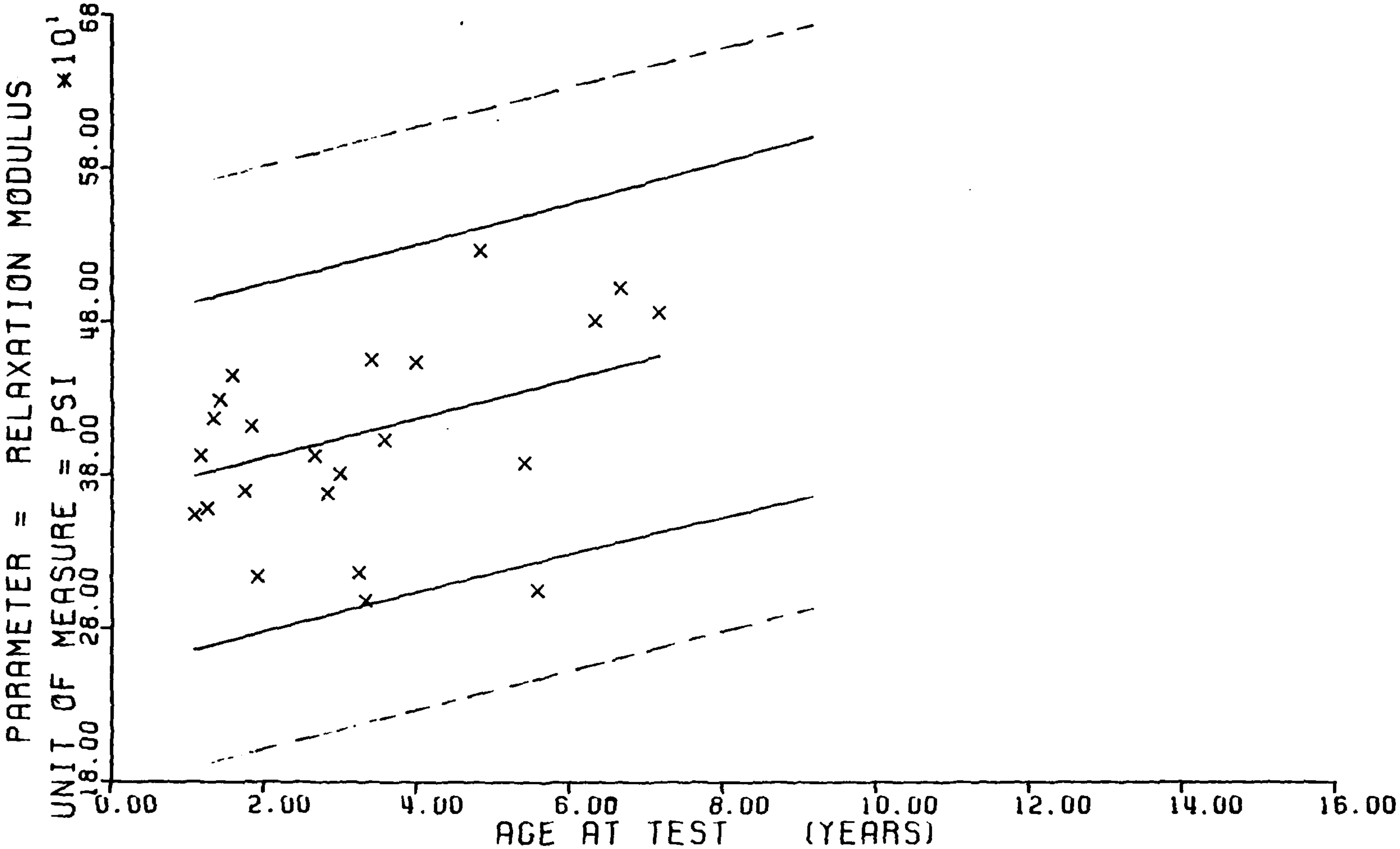
F = +2.0593140E+01   SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +6.7175779E+01

R = +3.4148715E-01   SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.3592665E-01

ι = +4.5379665E+00   SIGNIFICANCE OF ι = SIGNIFICANT S_E = +6.3339645E+01

N = 158   DEGREES OF FREEDOM = 156

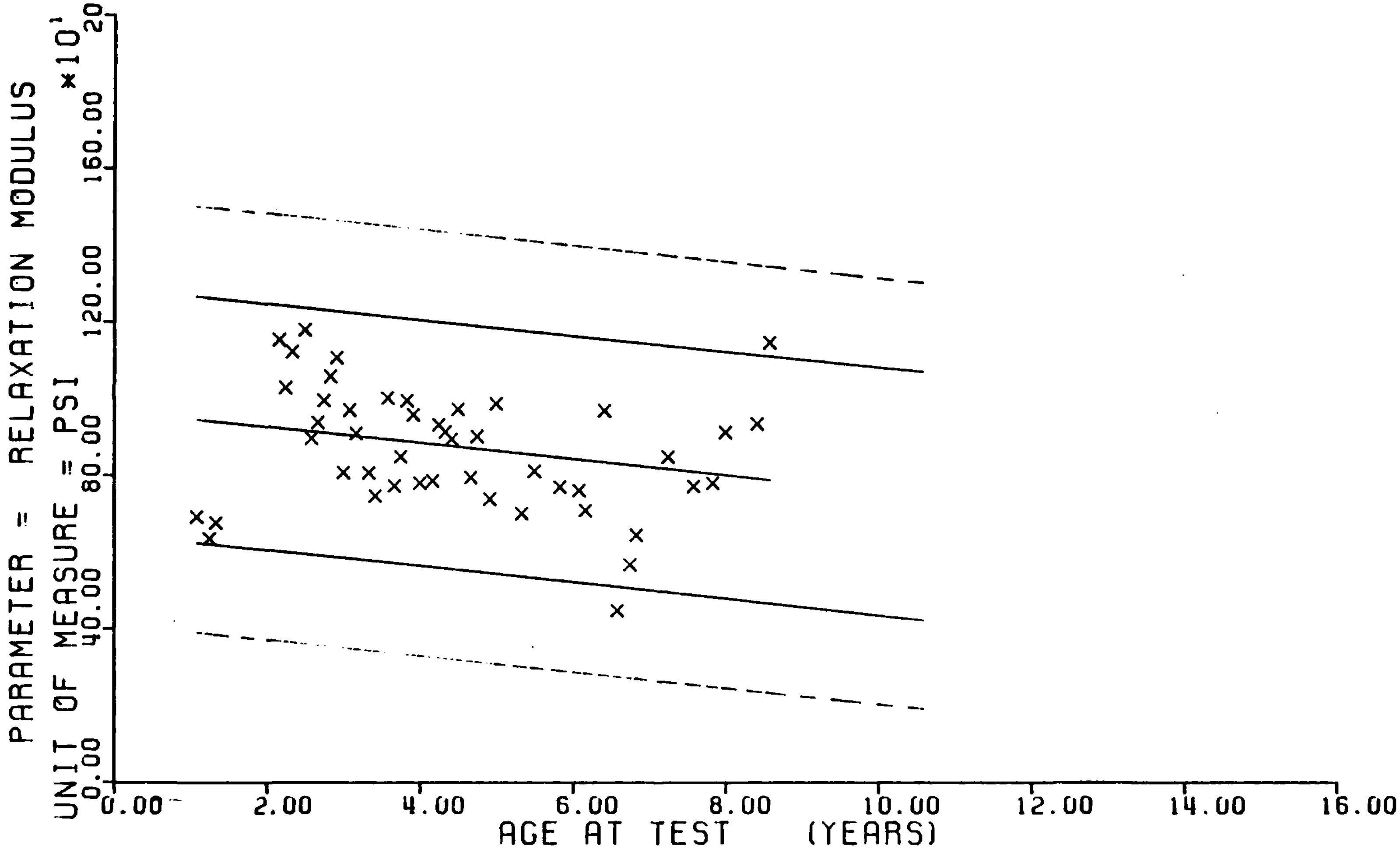
STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = 77 DEG F, AMB RH



STRESS RELAXATION MODULUS, ANB-3066 (ANB P-POLYMER LINED), 1000 SEC, 3% STRAIN

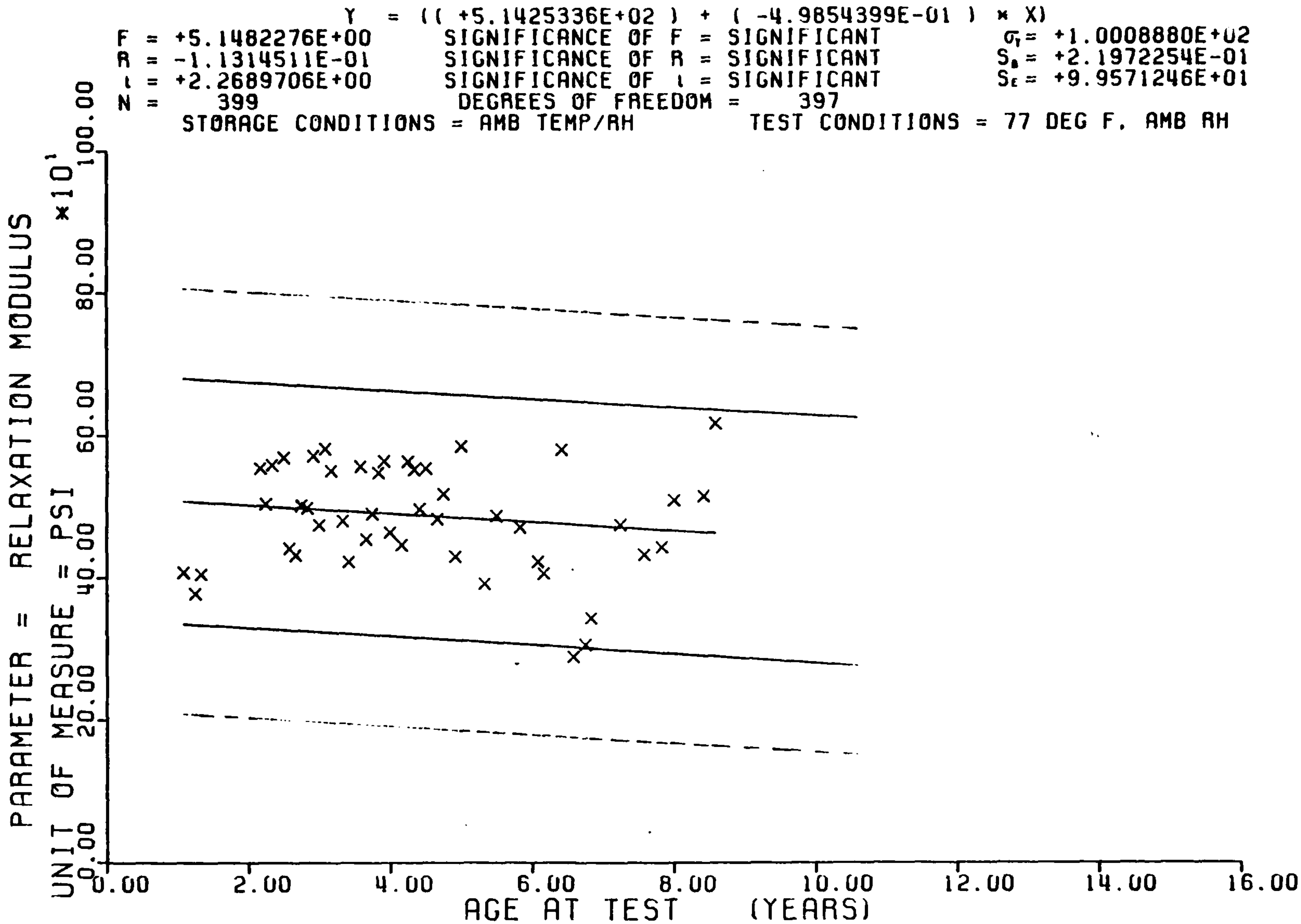
Figure 6-10

```
                Y  = (( +9.6820688E+02 ) + ( -1.7499184E+00 ) * X)
F = +1.8371595E+01     SIGNIFICANCE OF F = SIGNIFICANT        σ_Y = +1.8900816E+02
R = -2.1030763E-01     SIGNIFICANCE OF R = SIGNIFICANT        S_B = +4.0826708E-01
ι = +4.2862099E+00     SIGNIFICANCE OF ι = SIGNIFICANT        S_E = +1.8501361E+02
N =    399              DEGREES OF FREEDOM =    397
   STORAGE CONDITIONS = AMB TEMP/RH       TEST CONDITIONS = 77 DEG F, AMB RH
```



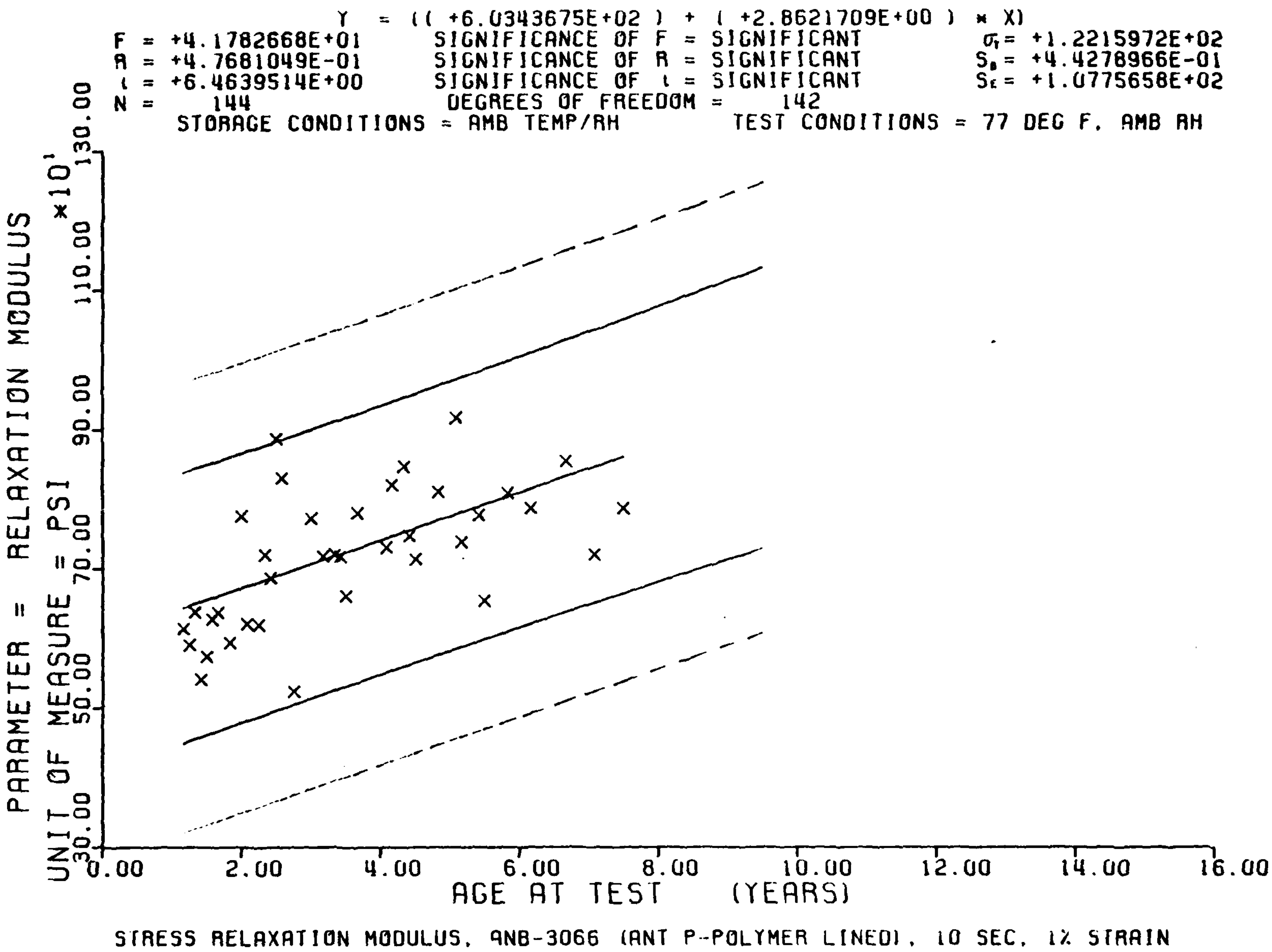
STRESS RELAXATION MODULUS, 9NB-3066 (ANT P-POLYMER UNLND), 10 SEC, 3% STRAIN

Figure 6-11



STRESS RELAXATION MODULUS, ANB-3066 (ANT P-POLYMER UNLND), 1000 SEC, 3% STRAIN

Figure 6-12



Y = ((+6.0343675E+02) + (+2.8621709E+00) * X)
F = +4.1782668E+01 SIGNIFICANCE OF F = SIGNIFICANT σT = +1.2215972E+02
R = +4.7681049E-01 SIGNIFICANCE OF R = SIGNIFICANT SB = +4.4278966E-01
t = +6.4639514E+00 SIGNIFICANCE OF t = SIGNIFICANT SE = +1.0775658E+02
N = 144 DEGREES OF FREEDOM = 142
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F. AMB RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI ×10¹
30.00
50.00
70.00
90.00
110.00
130.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
STRESS RELAXATION MODULUS, ANB-3066 (ANT P-POLYMER LINED), 10 SEC, 1% STRAIN

Figure 6-13

Y = ((+3.7414550E+02) + (+1.8031072E+00) * X)

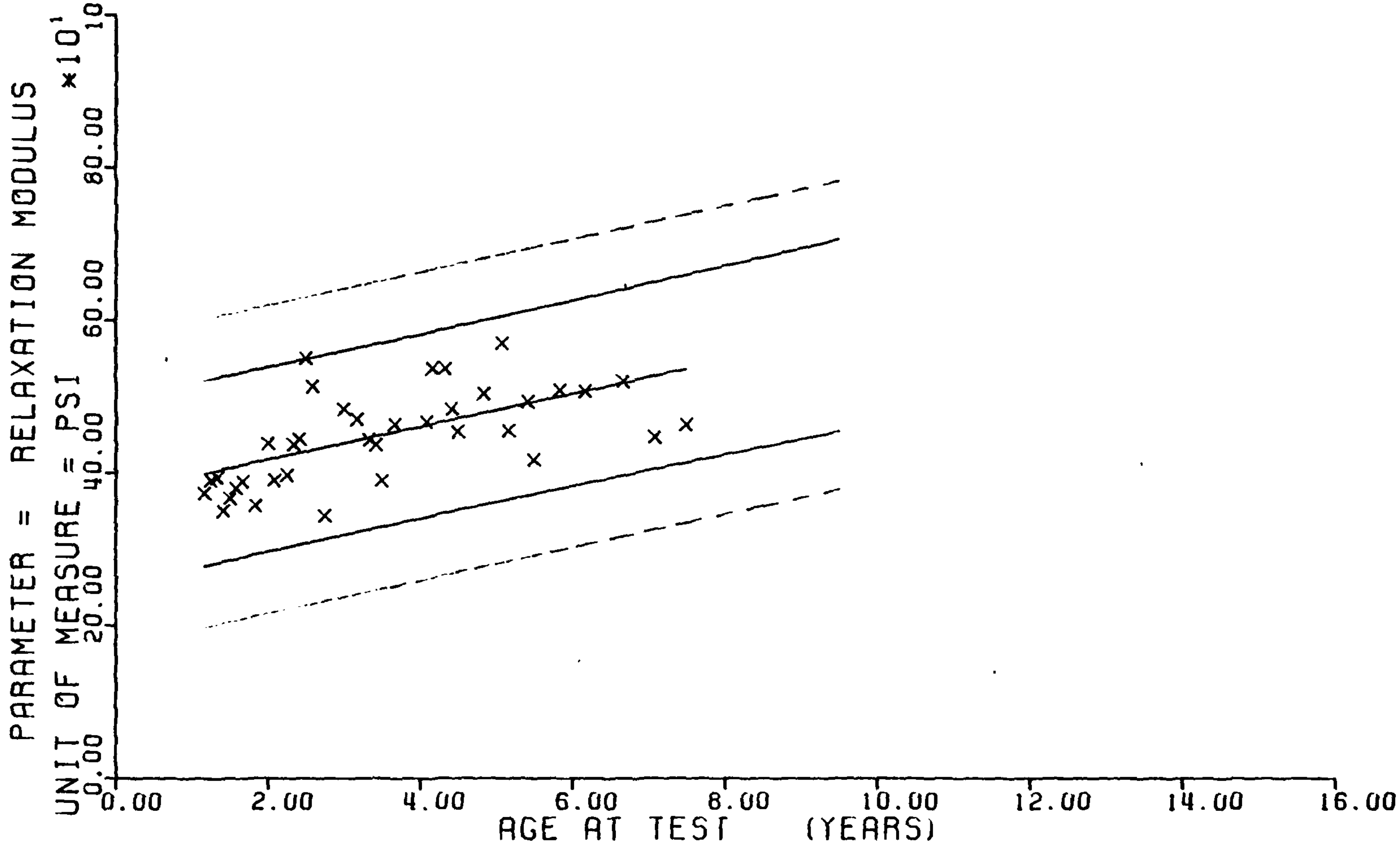
F = +4.2453540E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +7.6486784E+01

R = +4.7974831E-01 SIGNIFICANCE OF R = SIGNIFICANT S_a = +2.7673532E-01

ι = +6.5156381E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_ι = +6.7345863E+01

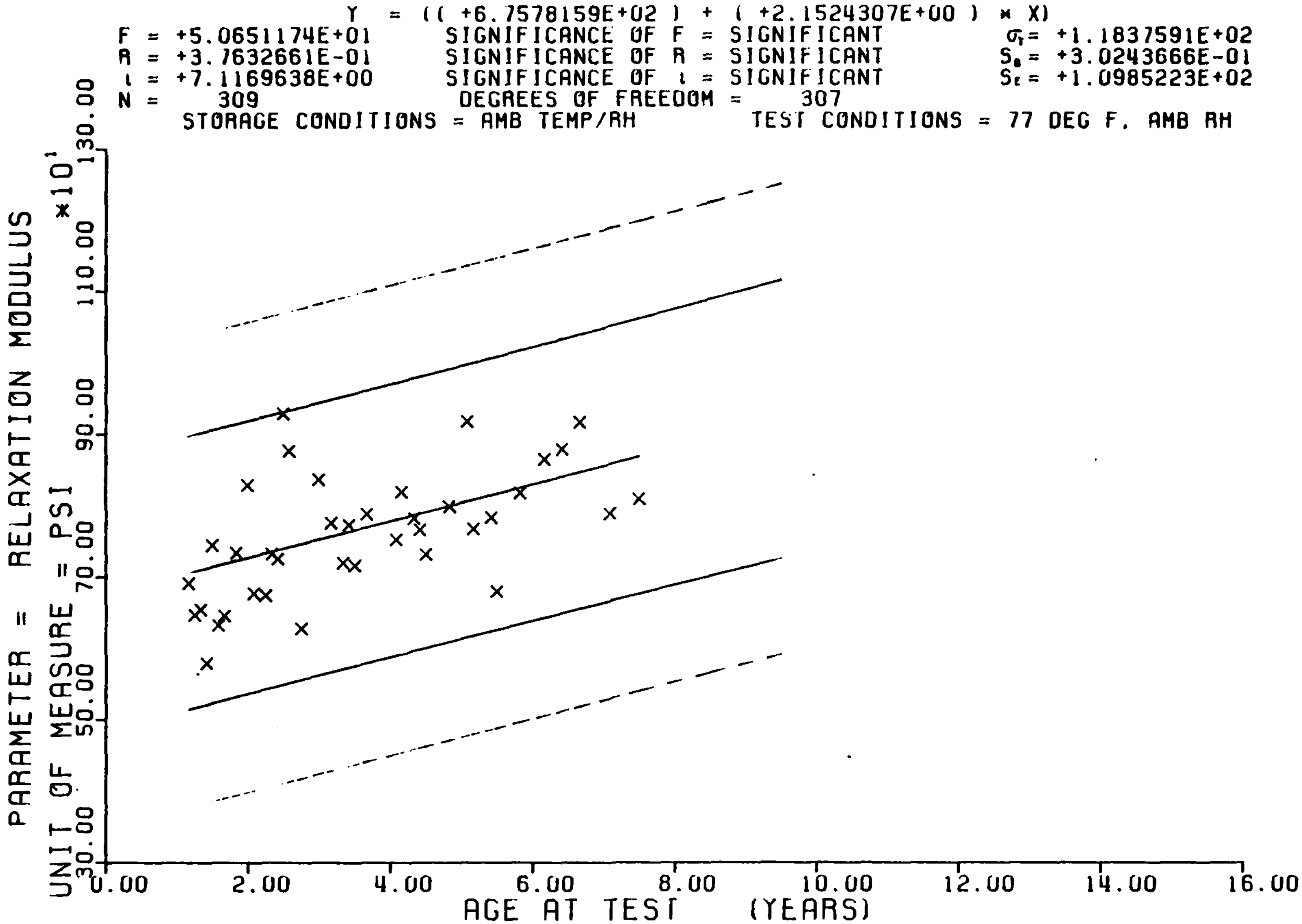
N = 144 DEGREES OF FREEDOM = 142

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG F, AMB RH



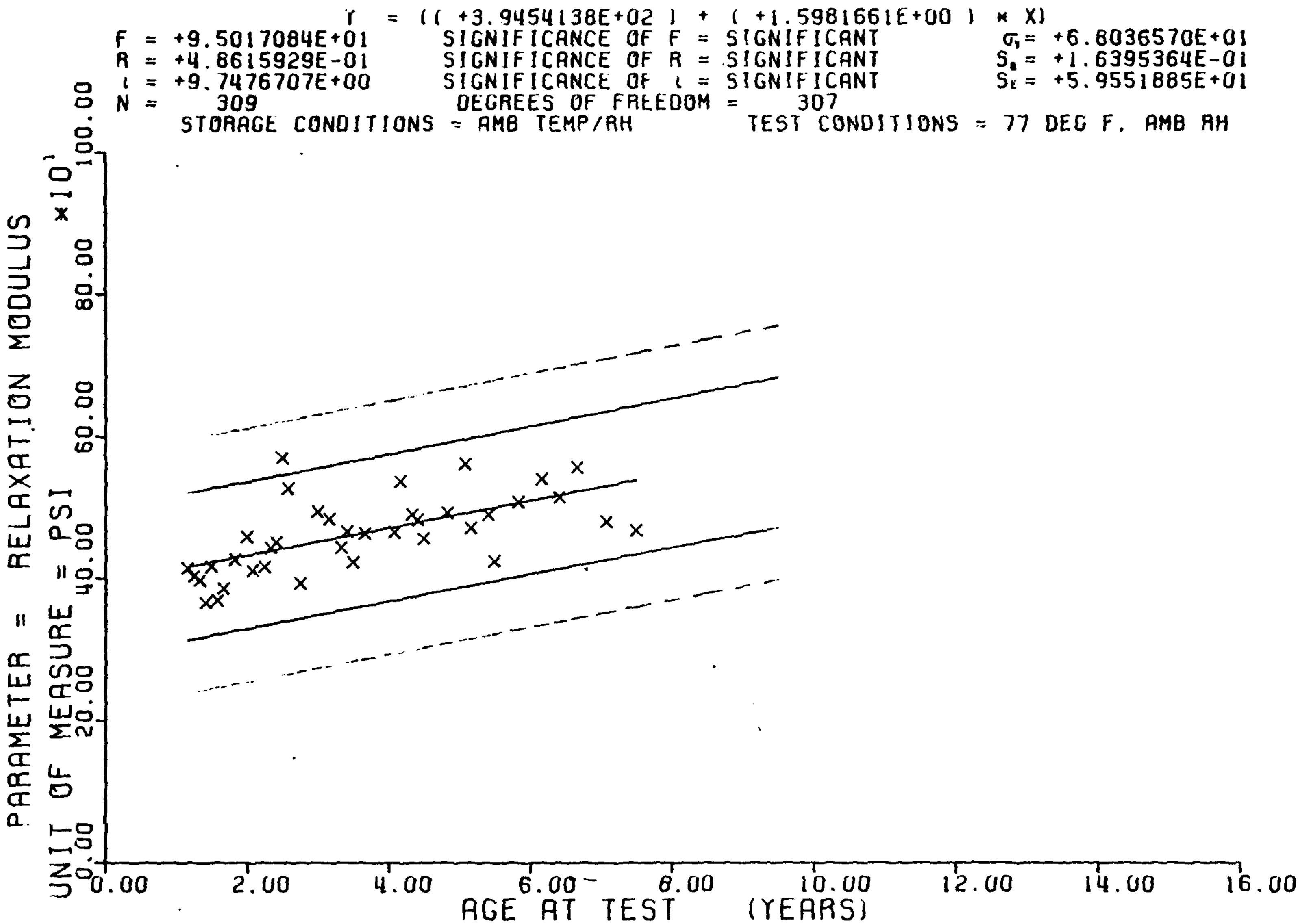
STRESS RELAXATION MODULUS, ANB-3066 (ANT P-POLYMER LINED), 1000 SEC, 1% STRAIN

Figure 6-14



STRESS RELAXATION MODULUS, ANB-3066 (ANT P-POLYMER LINED), 10 SEC, 3% STRAIN

Figure 6-15



STRESS RELAXATION MODULUS, ANB-3066 (ANT P-POLYMER LINED), 1000 SEC, 3% STRAIN

Figure 6-16

Y = ((+7.3579726E+02) + (-8.5378588E-01) × X)

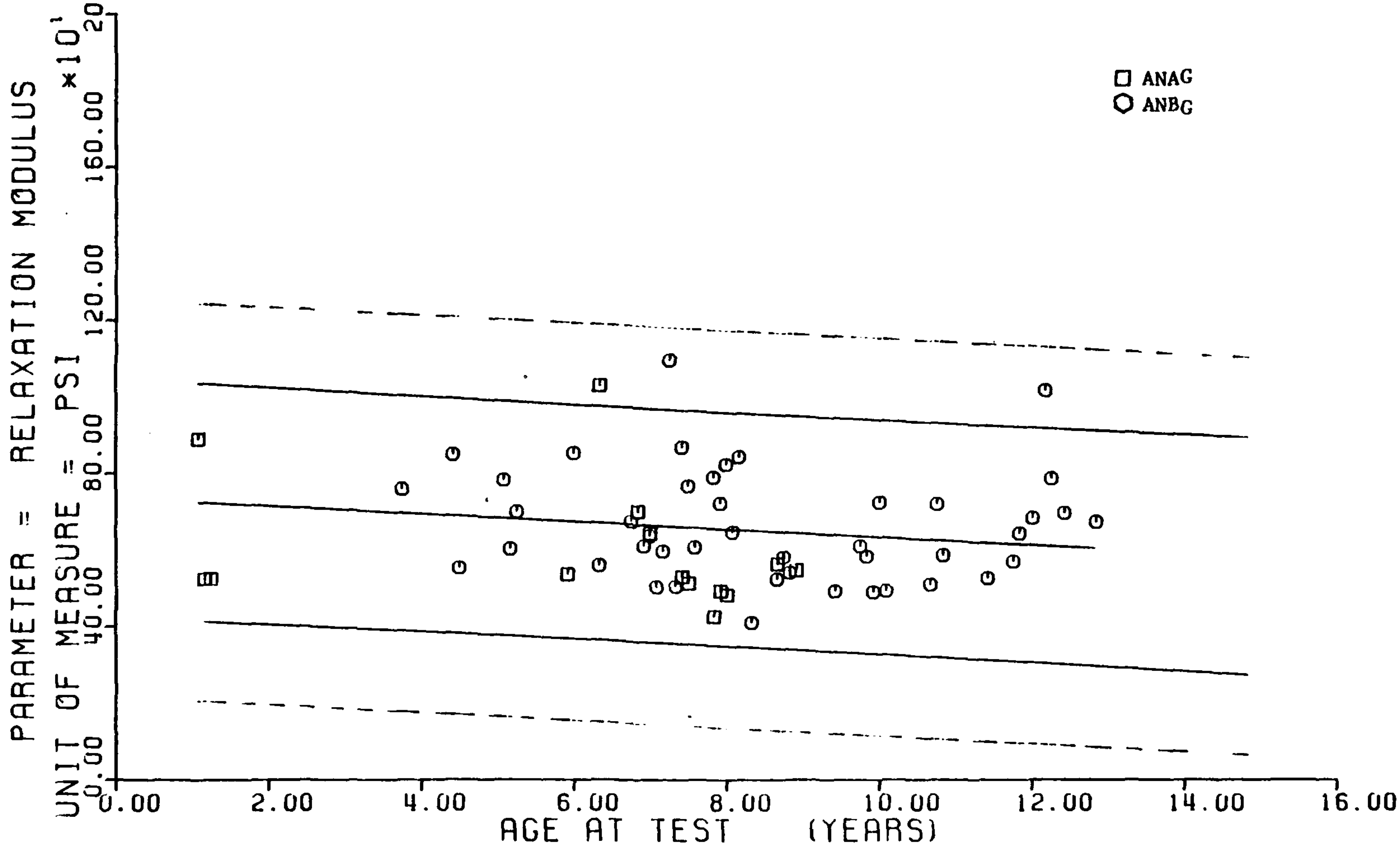
F = +4.1606488E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.7443472E+02

R = -1.3747087E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +4.1857033E-01

t = +2.0397668E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.7317809E+02

N = 218 DEGREES OF FREEDOM = 216

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STRESS RELAX MODULUS ANB-3066 (ANA & ANB G-POLY UNLND), 10 SEC, 1% STRAIN

Figure 6-17

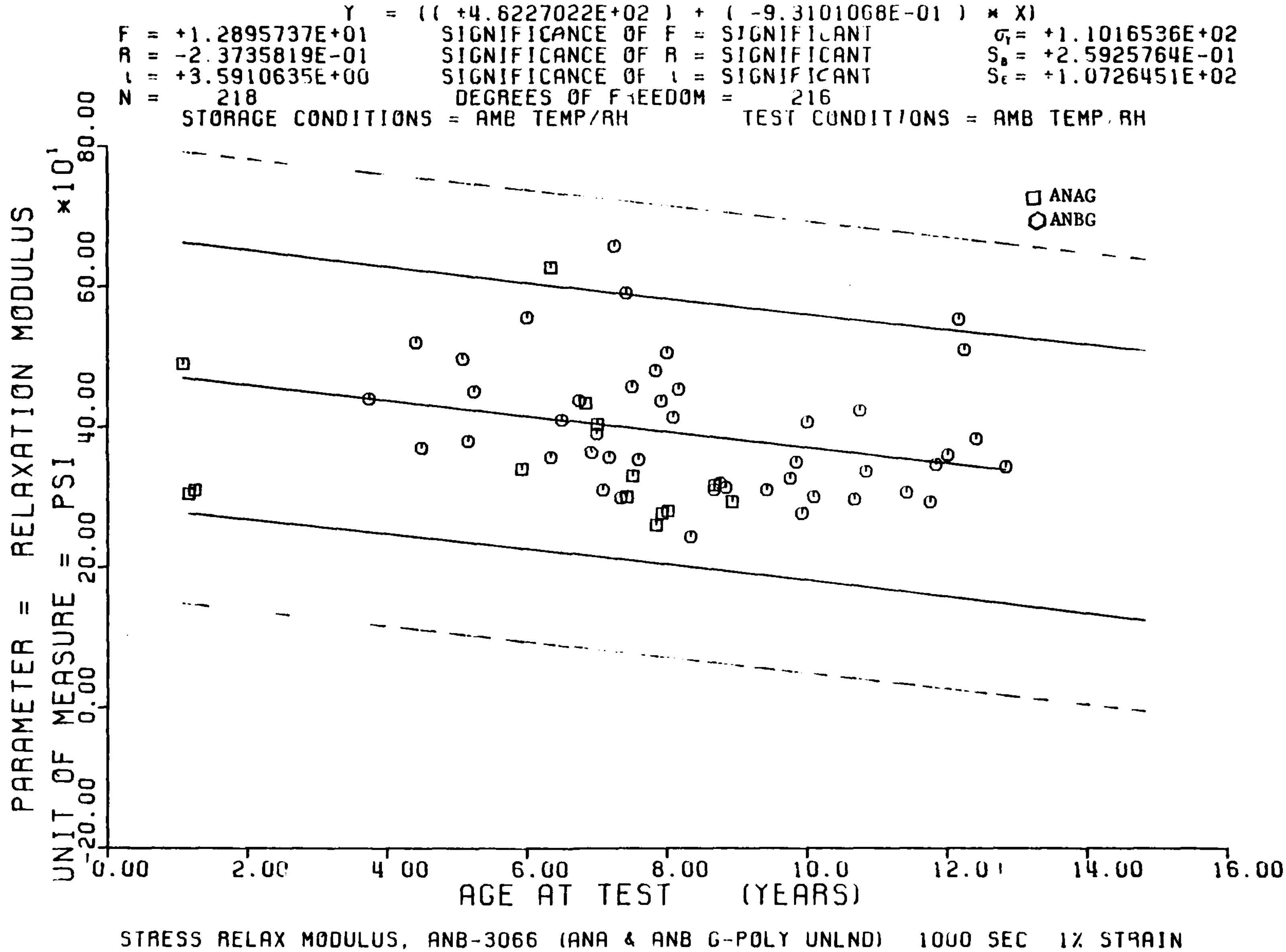

Y = ((+4.6227022E+02) + (-9.3101068E-01) * X)
F = +1.2895737E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.1016536E+02
R = -2.3735819E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.5925764E-01
t = +3.5910635E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.0726451E+02
N = 218 DEGREES OF FREEDOM = 216
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
ANAG
ANBG
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI
×10¹
80.00
60.00
40.00
20.00
0.00
-20.00
0.00
2.00
4.00
6.00
8.00
10.0
12.0
14.00
16.00
AGE AT TEST (YEARS)
STRESS RELAX MODULUS, ANB-3066 (ANA & ANB G-POLY UNLND) 1000 SEC 1% STRAIN

Figure 6-18

AD-A102 979   OGDEN AIR LOGISTICS CENTER HILL AFB UT   PROPELLANT AN--ETC   F/G 21/9.2
PROPELLANT SURVEILLANCE REPORT ANB-3066 PROPELLANT.(U)
DEC 80   E M DALABA

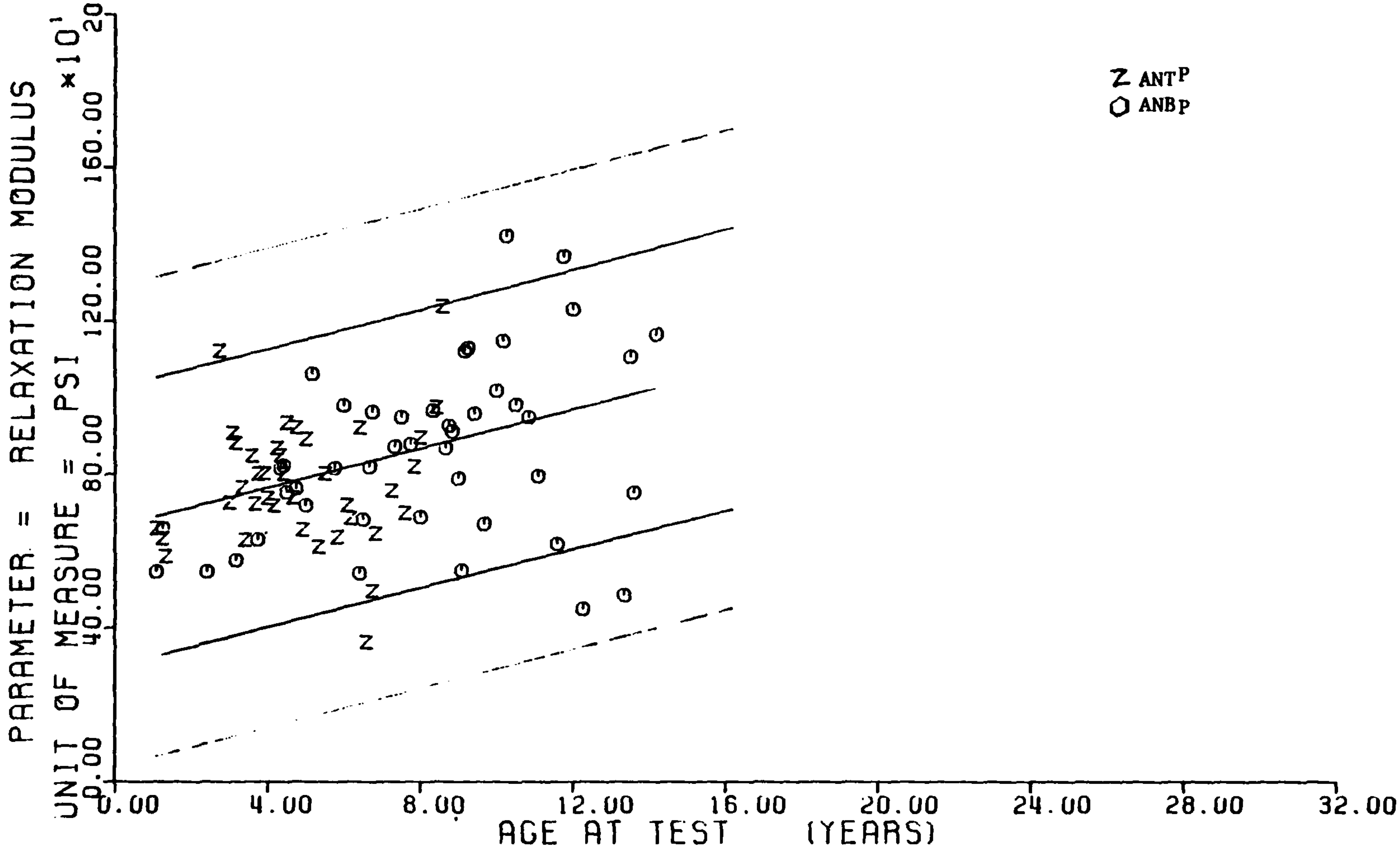
UNCLASSIFIED   MAKPH-450(80)   NL

2 of 2
AD
A102979

END
DATE
FILMED
9-81
DTIC

Y = ((+6.6234143E+02) + (+2.1379174E+00) * X)

F = +4.8244304E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +2.2292216E+02
R = +3.6097642E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.0779949E-01
t = +6.9458120E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +2.0821418E+02
N = 324 DEGREES OF FREEDOM = 322
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STRESS RELAX MODULUS, ANB-3066 (ANT & ANB P POLY UNLND), 10 SEC, 1% STRAIN

Figure 6-19

Y = ((+4.2277093E+02) + (+8.0032087E-01) * X)

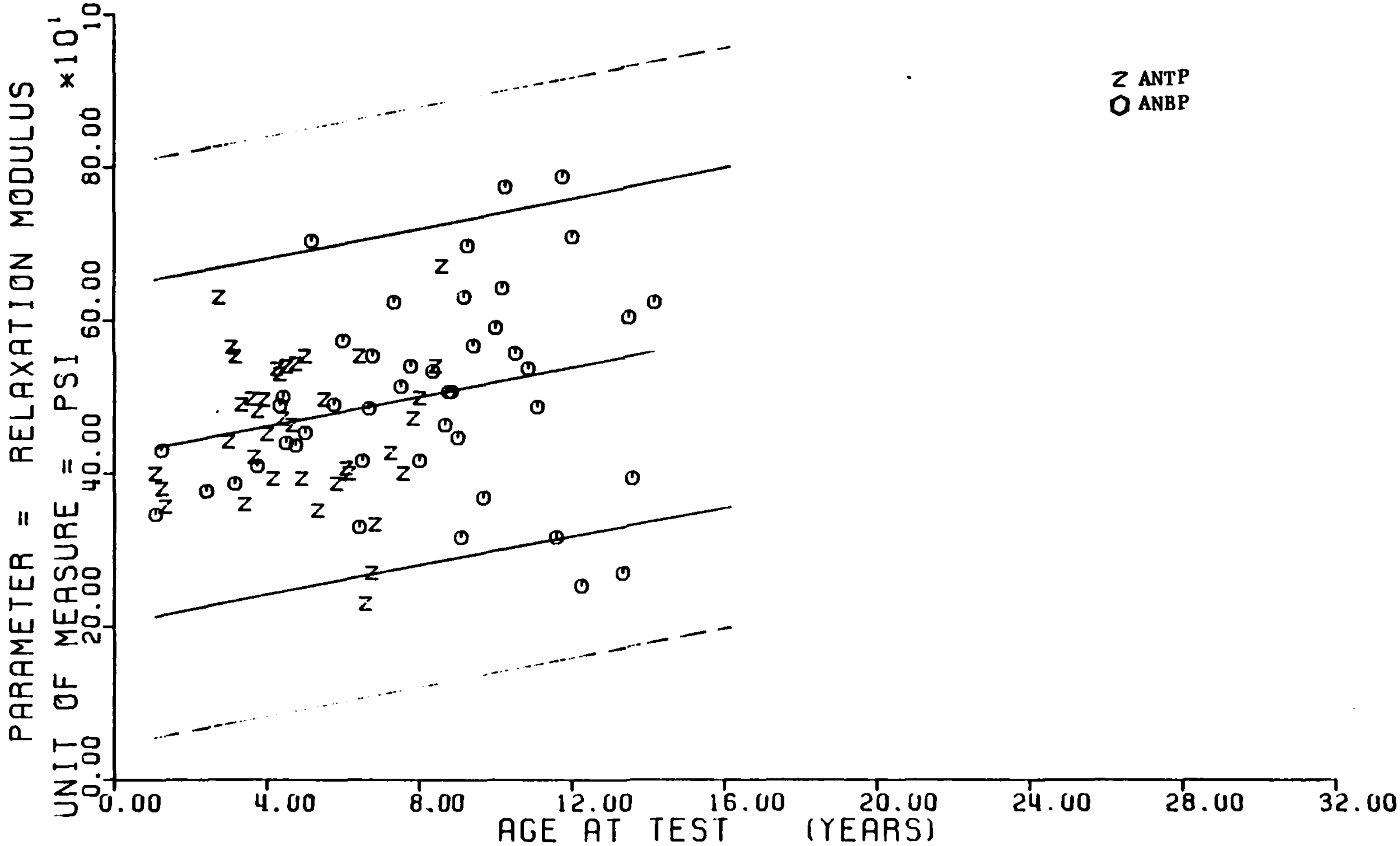
F = +1.8425693E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1 2948055E+02

R = +2.3264876E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.8644563E-01

t = +4.2925160E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.2612310E+02

N = 324 DEGREES OF FREEDOM = 322

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STRESS RELAX MODULUS, ANB-3066 (ANT & ANB P-POLY UNLND), 1000 SEC, 1% STRAIN

Figure 6-20

Y = ((+6.0726468E+02) + (+2.2996467E+00) * X)

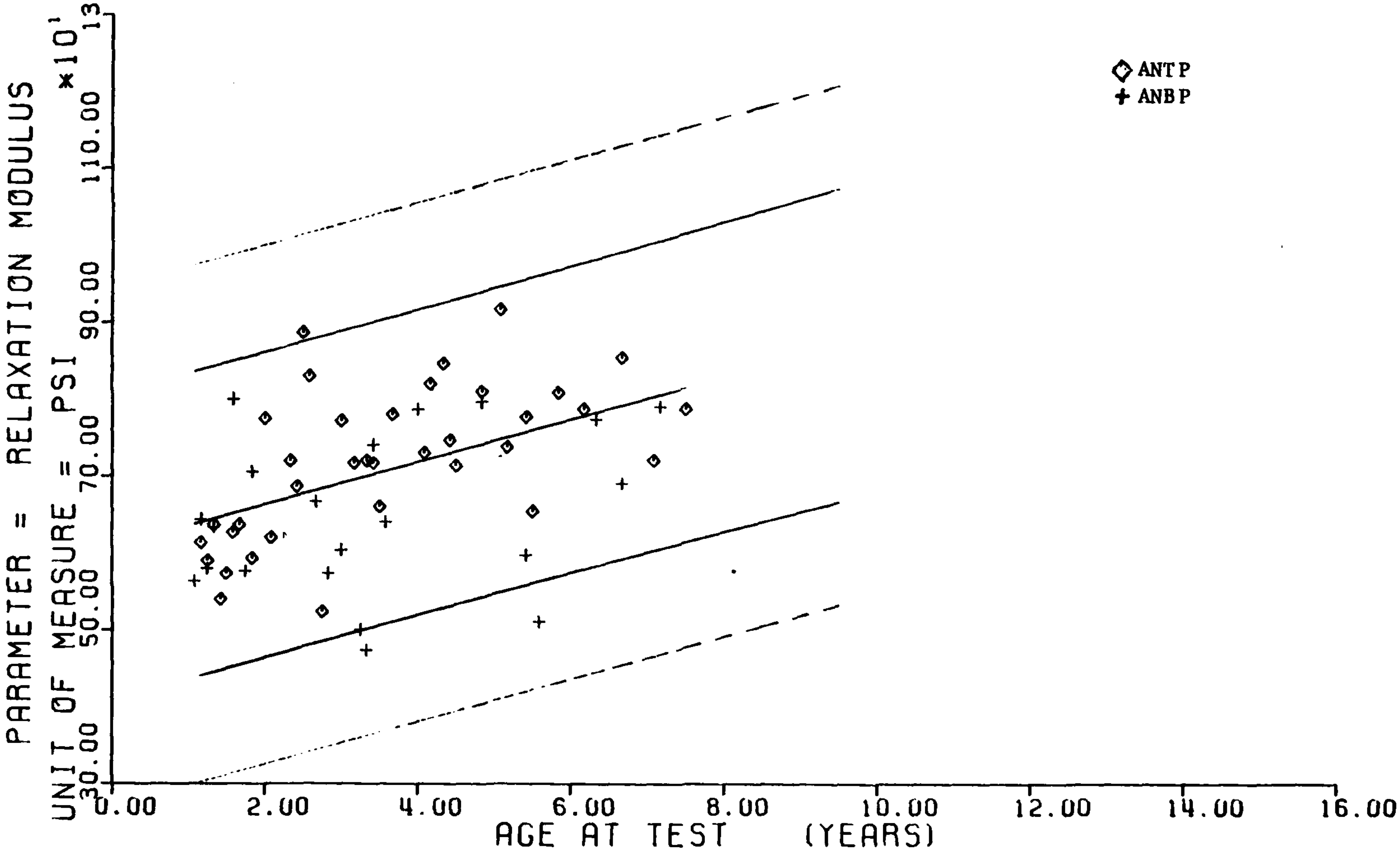
F = +3.9084643E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.2198399E+02

R = +3.9297975E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.6783924E-01

t = +6.2517711E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.1243180E+02

N = 216 DEGREES OF FREEDOM = 214

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STRESS RELAX MODULUS, ANB-3066 (ANT & ANB P-POLY LINED), 10 SEC. 1% STRAIN

Figure 6-21

Y = ((+3.7756389E+02) + (+1.4305343E+00) * X)

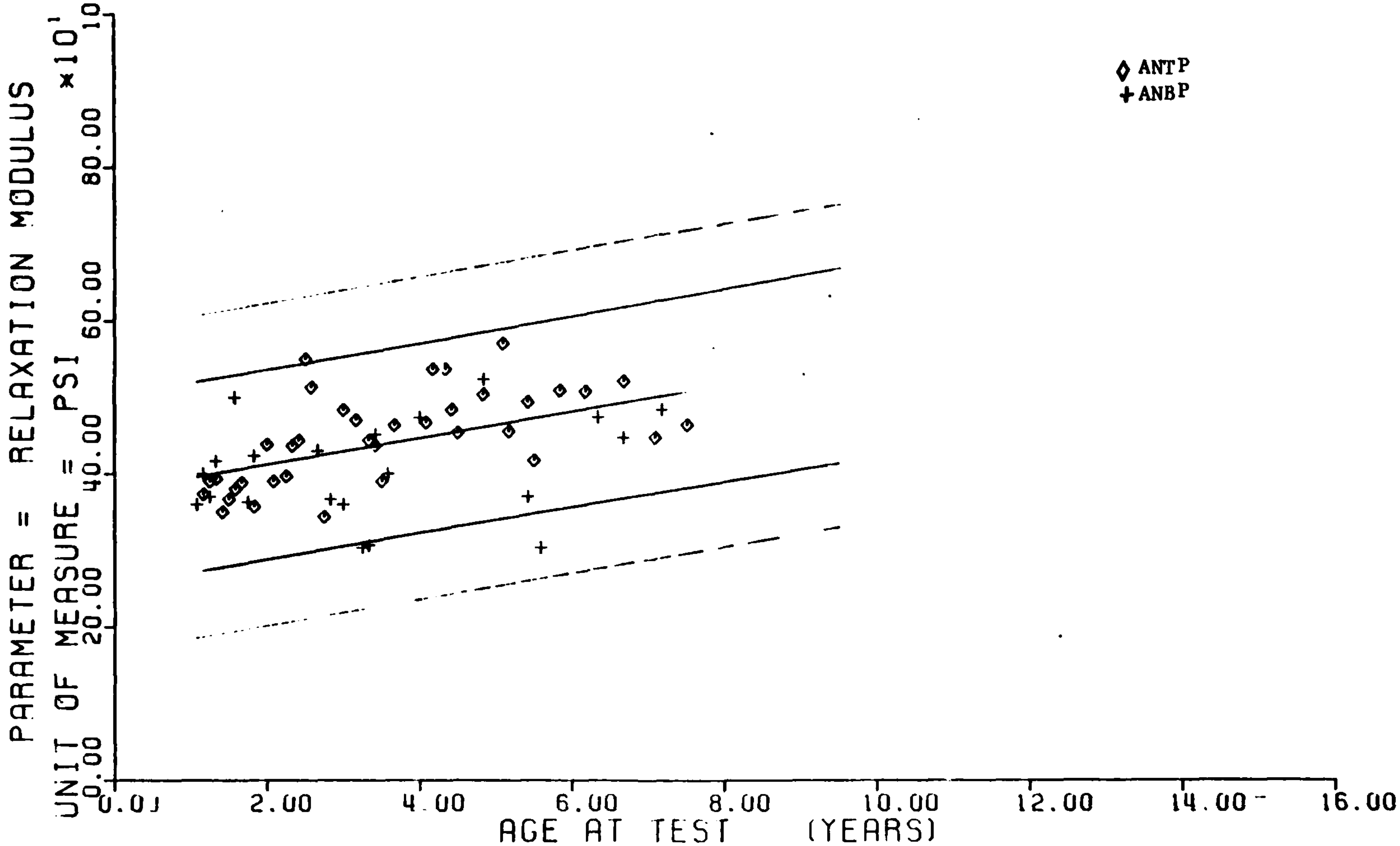
F = +3.8865224E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +7.6063122E+01

R = +3.9204510E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.2946566E-01

t = +6.2341979E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +7.0137265E+01

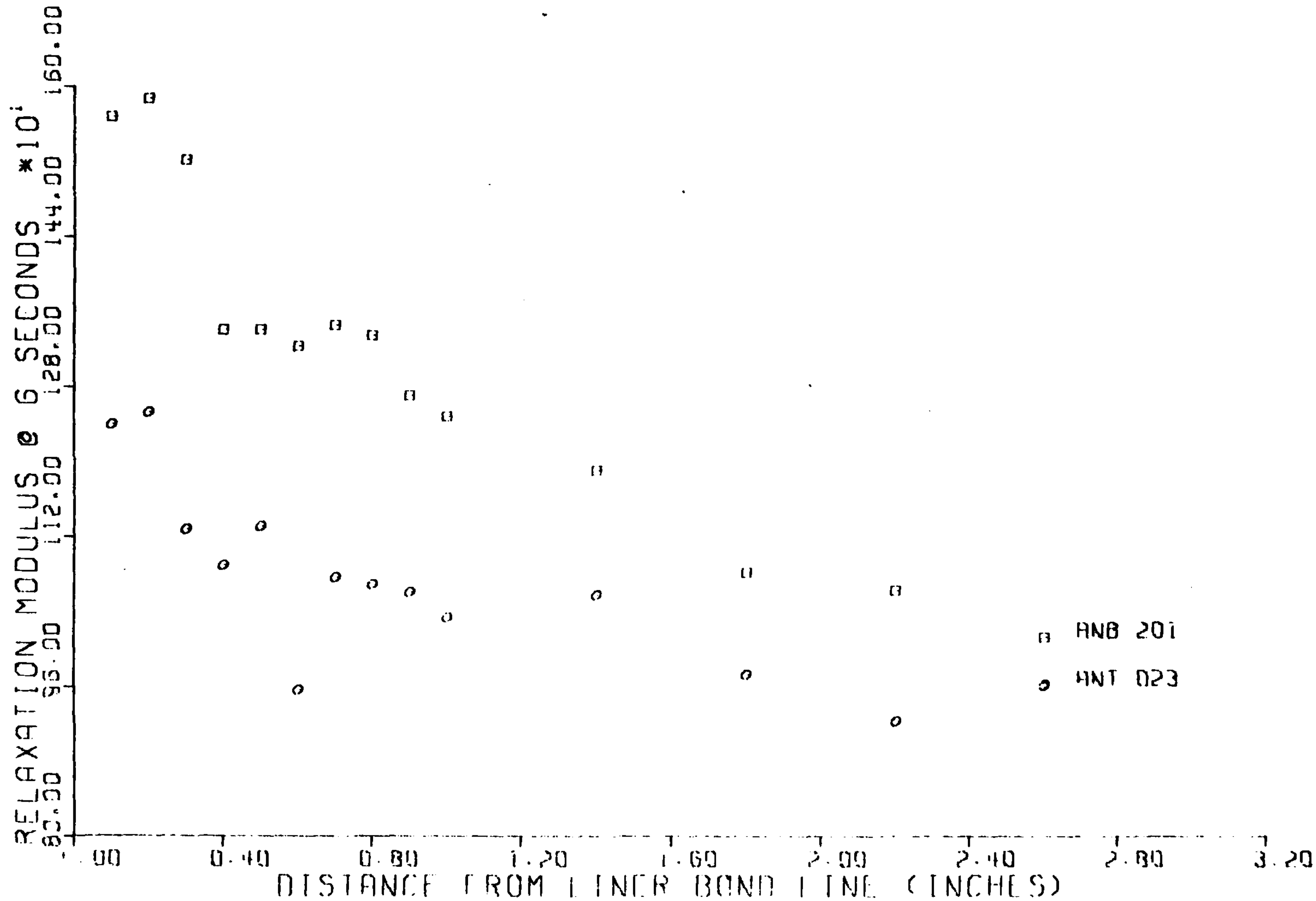
N = 216 DEGREES OF FREEDOM = 214

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



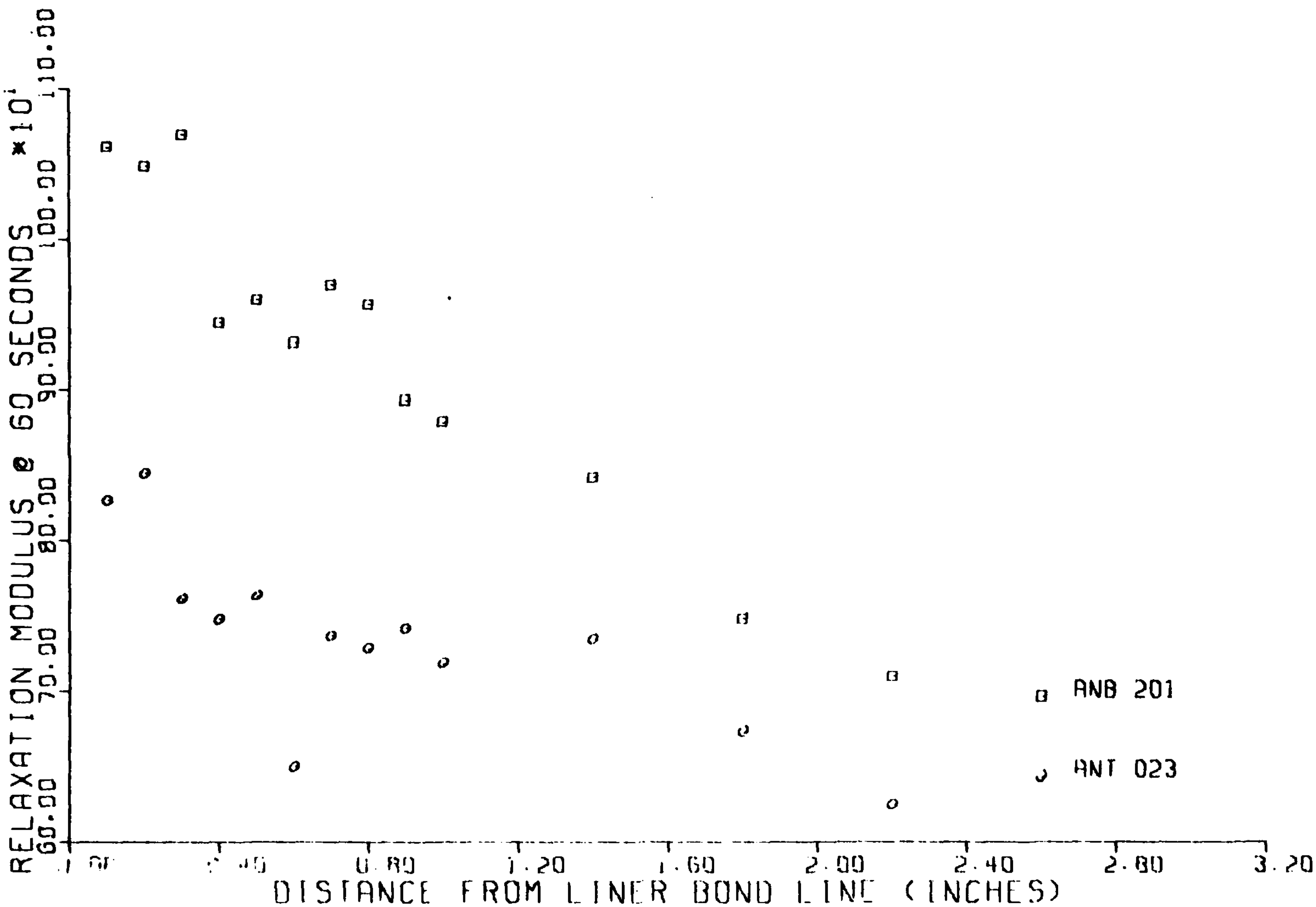
STRESS RELAX MODULUS, ANB-3066 (ANT & ANB P-POLY LINED), 10.0 SEC, 1% STRAIN

Figure 6-22



ANB/ANT P GRADIENT STRESS RELAXATION MODULUS @ 3%

Figure 6-23



ANB/ANT P GRADIENT STRESS RELAXATION MODULUS @ 3%

Figure 6-24

SECTION VII

THERMAL COEFFICIENT OF LINEAR EXPANSION

Thermal coefficient of linear expansion is run on the DuPont 990 Thermal Analyzer using the thermomechanical analyzer with expansion probe. The specimen used is a wafer approximately .200" (.508 cm) thick by .33" (.84 cm) diameter. The specimen is cooled to -110°C (-166°F) then heated at 5°C/min (9°F/min) to 40°C (104°F). The glass point (Tg), TCLE below Tg and TCLE above Tg are determined.

According to ASPC, where a volume coefficient of expansion is determined, the glass point for propellant stored at 80°F ranges from -91°C (-132°F) to -79.5°C (-111°F). All systems show a significant lowering of the glass point.

Expansion below the glass point is not considered to be a sigificant factor in analysis. This region is linear. Lined cartons of ANB "G" and "P" do not show a trend. Others show a sigificant increase.

TCLE above Tg is not significant for ANB "G" lined cartons. ANB "G" and "P" unlined cartons show a significant increase. ANB "P" lined and ANT "P" unlined and lined cartons show a significant decrease in this parameter.

TABLE 7-1

TCLE

Significance of Regression Slopes

SYSTEM	Tg	Fig	Below Tg	Fig	Above Tg	Fig
ANB "G" Unlined	Sig dec	7-1	Sig inc	7-2	Sig inc	7-3
ANB "G" Lined	Sig dec		NS		NS	
ANB "P" Unlined	Sig dec	7-4	Sig inc	7-5	Sig inc	7-6
ANB "P" Lined	Sig dec		NS		Sig dec	
ANT "P" Unlined	Sig dec	7-7	Sig inc	7-8	Sig dec	7-9
ANT "P" Lined	Sig dec	7-10	Sig inc	7-11	Sig dec	7-12

NS = Not significantly different from zero slope
Sig dec = Negative slope
Sig inc = Positive slope

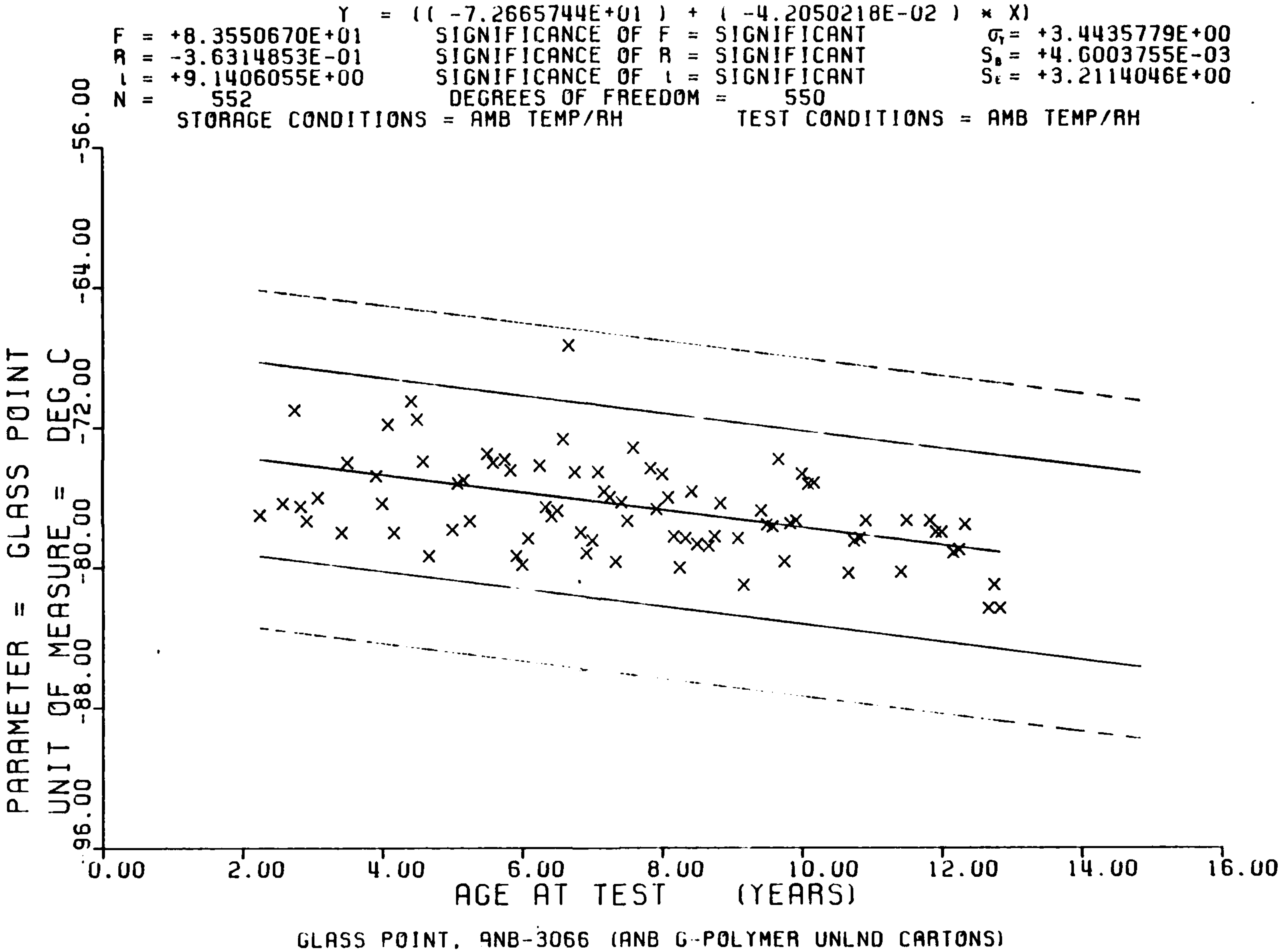
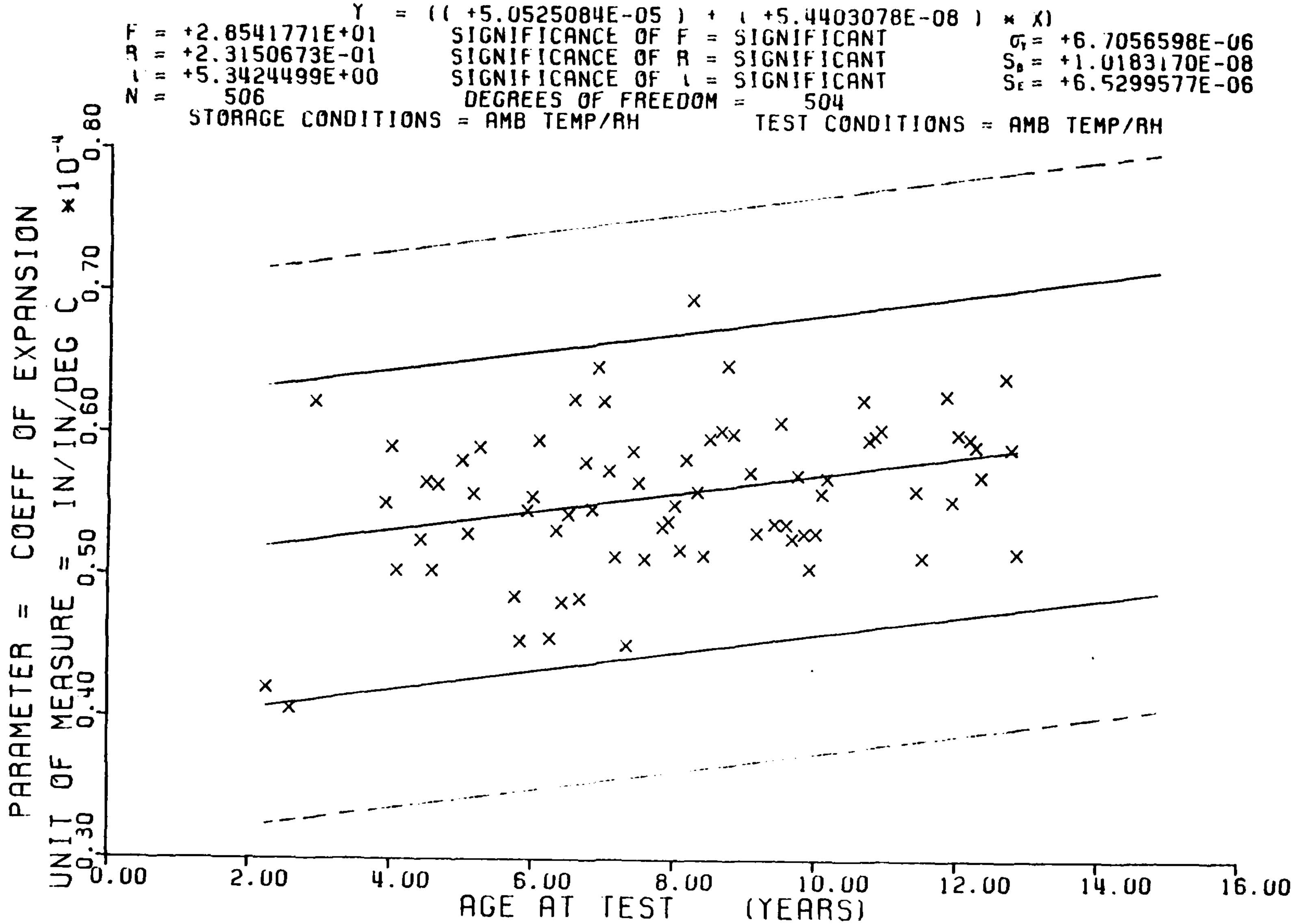

Y = ((-7.2665744E+01) + (-4.2050218E-02) * X)
F = +8.3550670E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +3.4435779E+00
R = -3.6314853E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +4.6003755E-03
t = +9.1406055E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +3.2114046E+00
N = 552 DEGREES OF FREEDOM = 550
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = GLASS POINT
UNIT OF MEASURE = DEG C
-56.00
-64.00
-72.00
-80.00
-88.00
96.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
GLASS POINT, ANB-3066 (ANB G-POLYMER UNLND CARTONS)

Figure 7-1

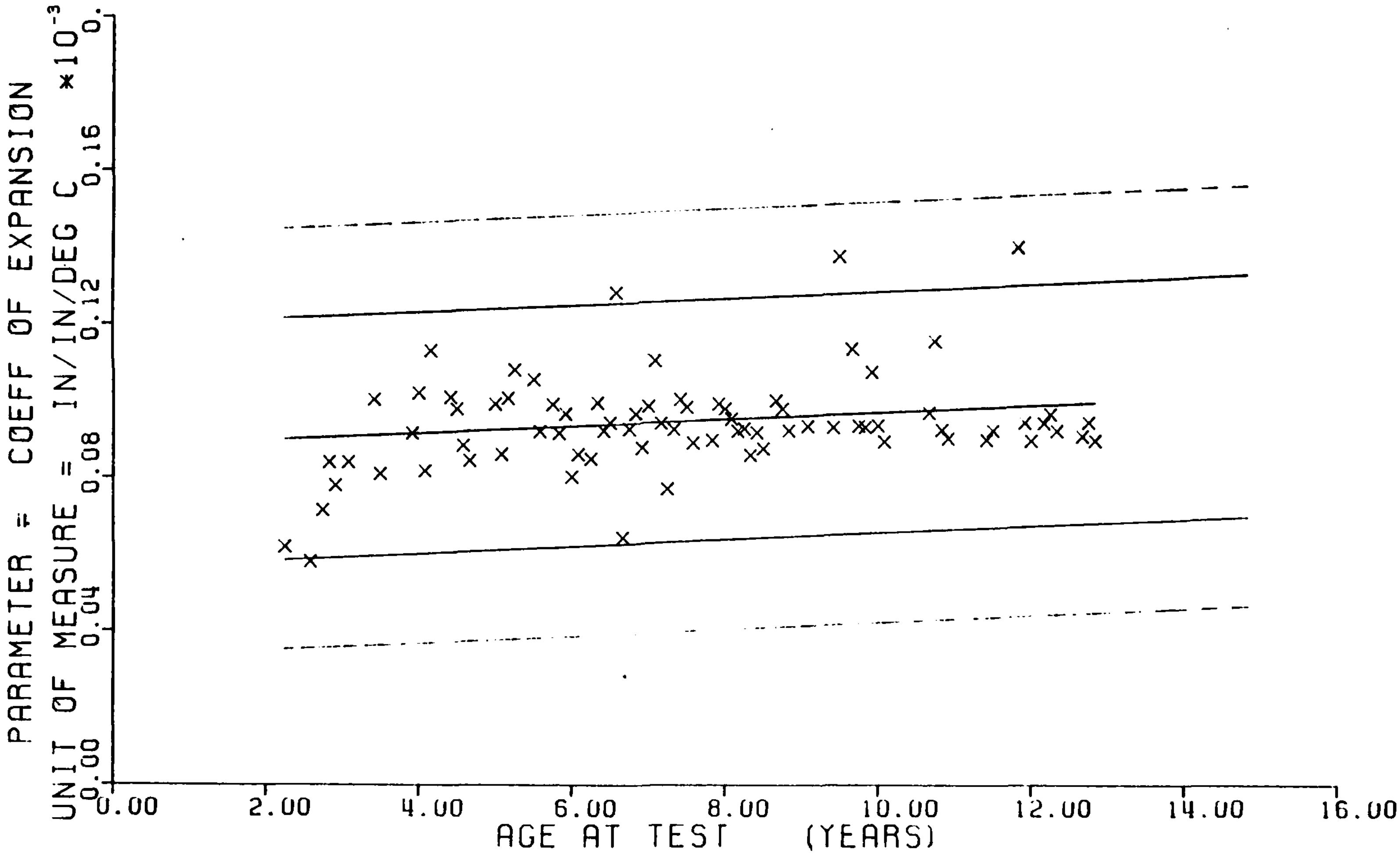


TCLE BELOW GLASS POINT, ANB-3066 (ANB G-POLYMER UNLND CARTONS)

Figure 7-2

Y = ((+8.7970235E-05) + (+7.5021302E-08) * X)

F = +7.9151916E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.8383270E-05
R = +1.2532912E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.6665755E-08
t = +2.8133950E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.8256698E-05
N = 498 DEGREES OF FREEDOM = 496
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TCLE ABOVE GLASS POINT, ANB-3066 (ANB G-POLYMER UNLND CARTONS)

Figure 7-3

Y = ((-7.3401583E+01) + (-3.5206492E-02) * X)

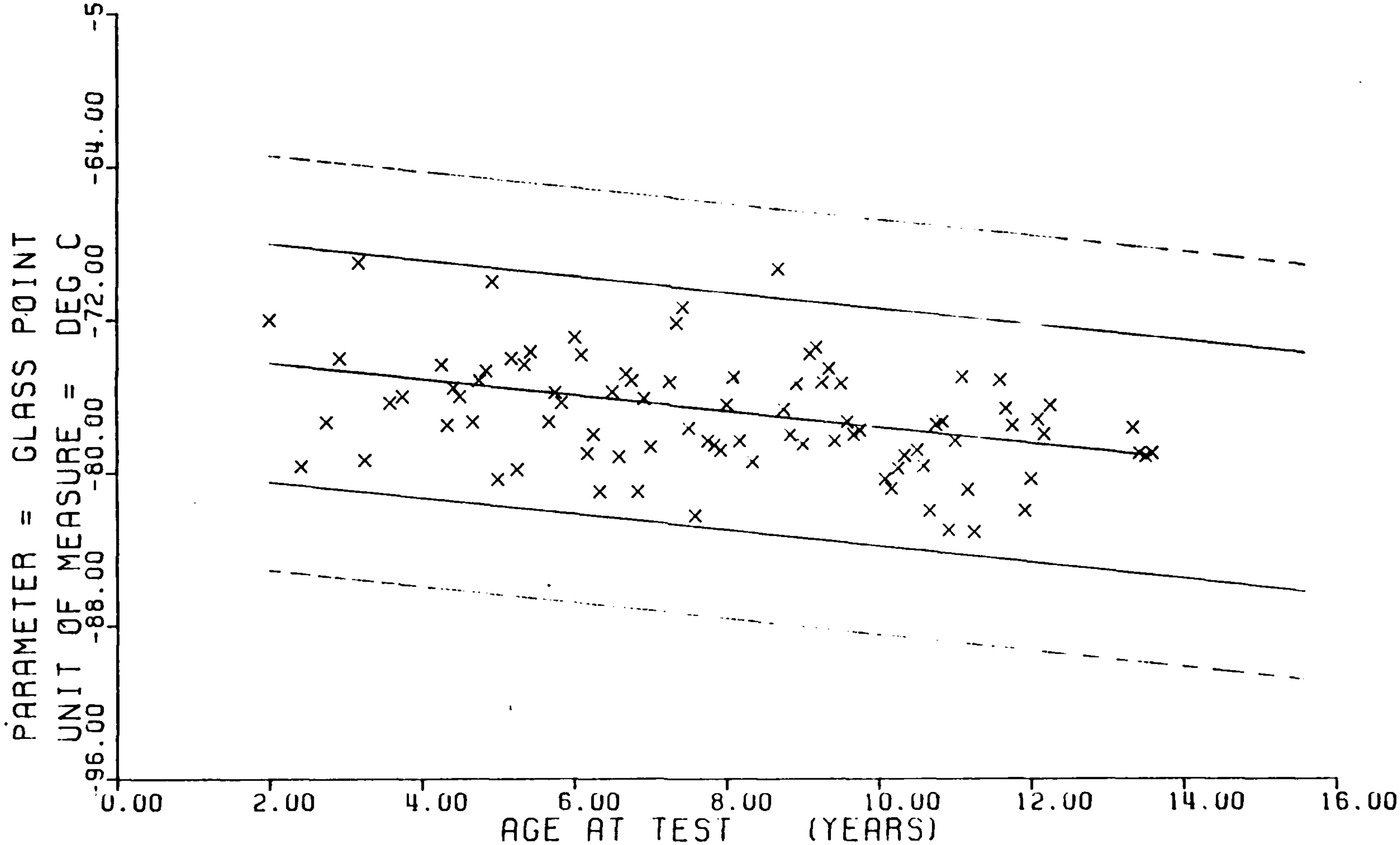
F = +5.1736020E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +3.7770774E+00

R = -2.9444581E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +4.8947019E-03

ι = +7.1927755E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +3.6129428E+00

N = 547 DEGREES OF FREEDOM = 545

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



GLASS POINT, ANB-3066 (ANB P-POLYMER UNLND CARTONS)

Figure 7-4

Y = ((+5.1016841E-05) + (+5.7658916E-08) * X)

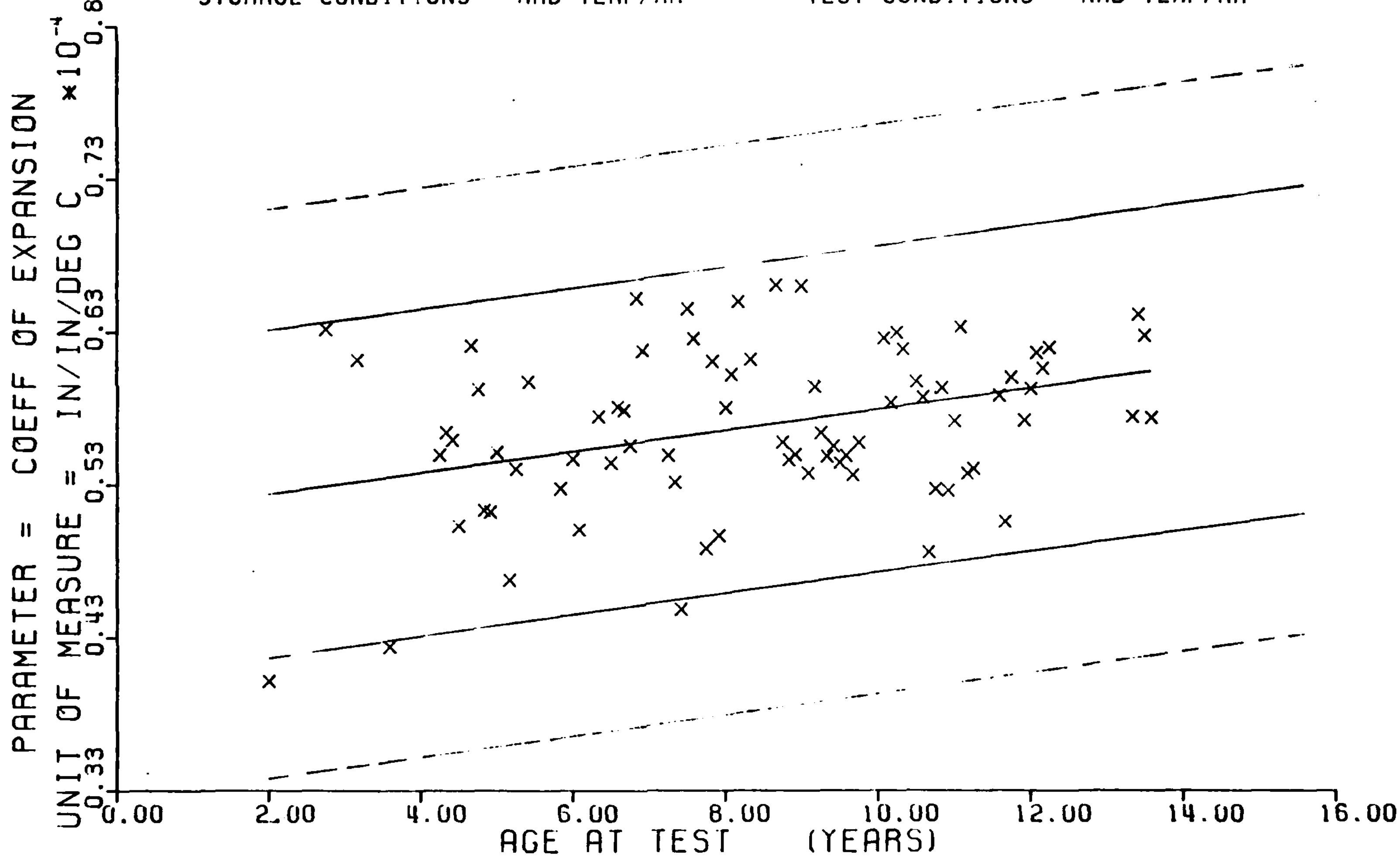
F = +4.0960634E+01   SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +6.4436277E-06

R = +2.7440979E-01   SIGNIFICANCE OF R = SIGNIFICANT S_B = +9.0091358E-09

ι = +6.4000495E+00   SIGNIFICANCE OF ι = SIGNIFICANT S_E = +6.2024314E-06

N = 505   DEGREES OF FREEDOM = 503

STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = AMB TEMP/RH



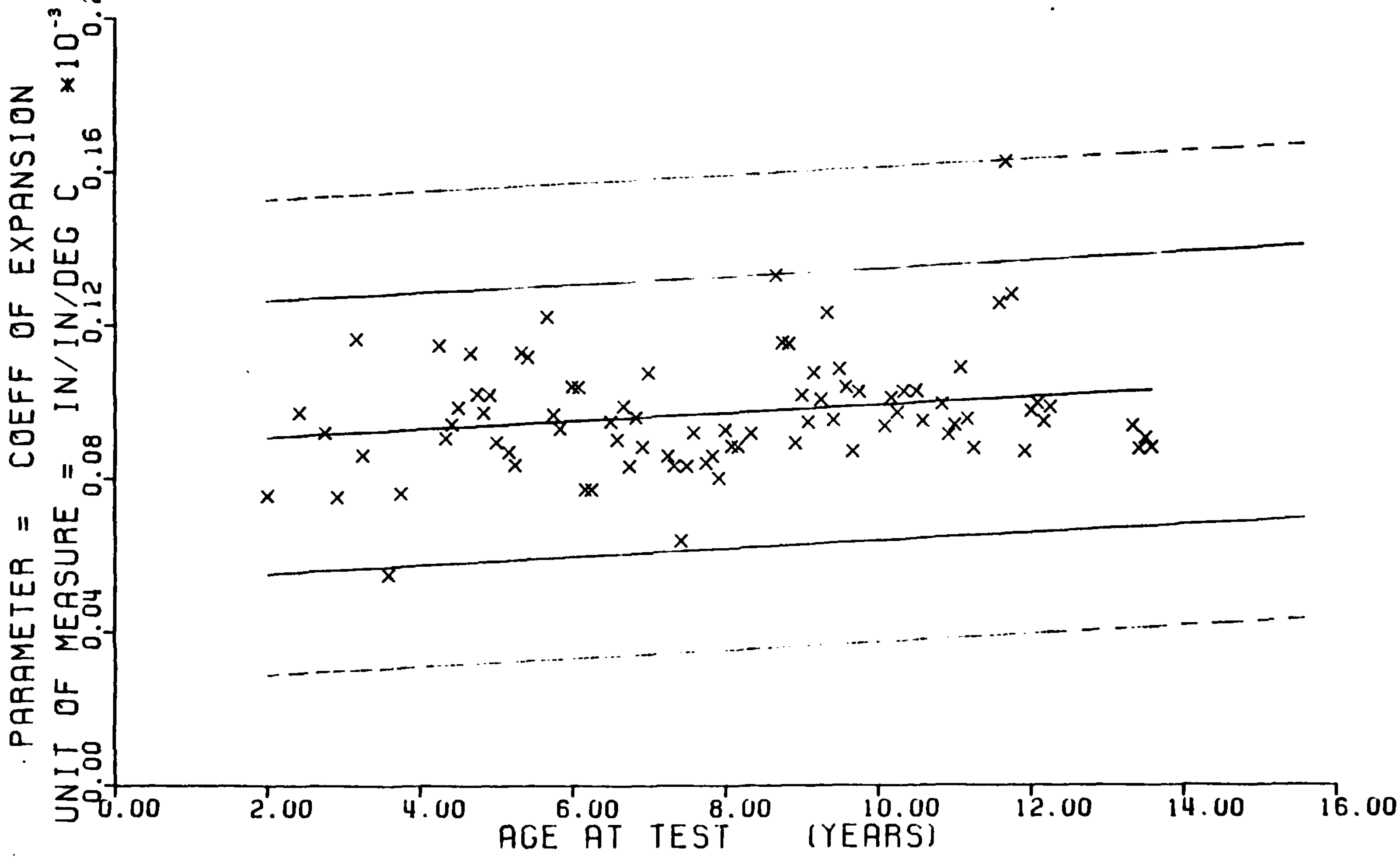
TCLE BELOW GLASS POINT, ANB-3066 (ANB P-POLYMER UNLND CARTONS)

Figure 7-5

Y = ((+8.8493186E-05) + (+8.9286053E-08) * X)

F = +9.9589215E+00	SIGNIFICANCE OF F = SIGNIFICANT	σ_Y = +2.0814707E-05
R = +1.3734286E-01	SIGNIFICANCE OF R = SIGNIFICANT	S_B = +2.8292900E-08
ι = +3.1557759E+00	SIGNIFICANCE OF ι = SIGNIFICANT	S_E = +2.0637349E-05
N = 520	DEGREES OF FREEDOM = 518	

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TCLE ABOVE GLASS POINT, ANB-3066 (ANB P-POLYMER UNLND CARTONS)

Figure 7-6

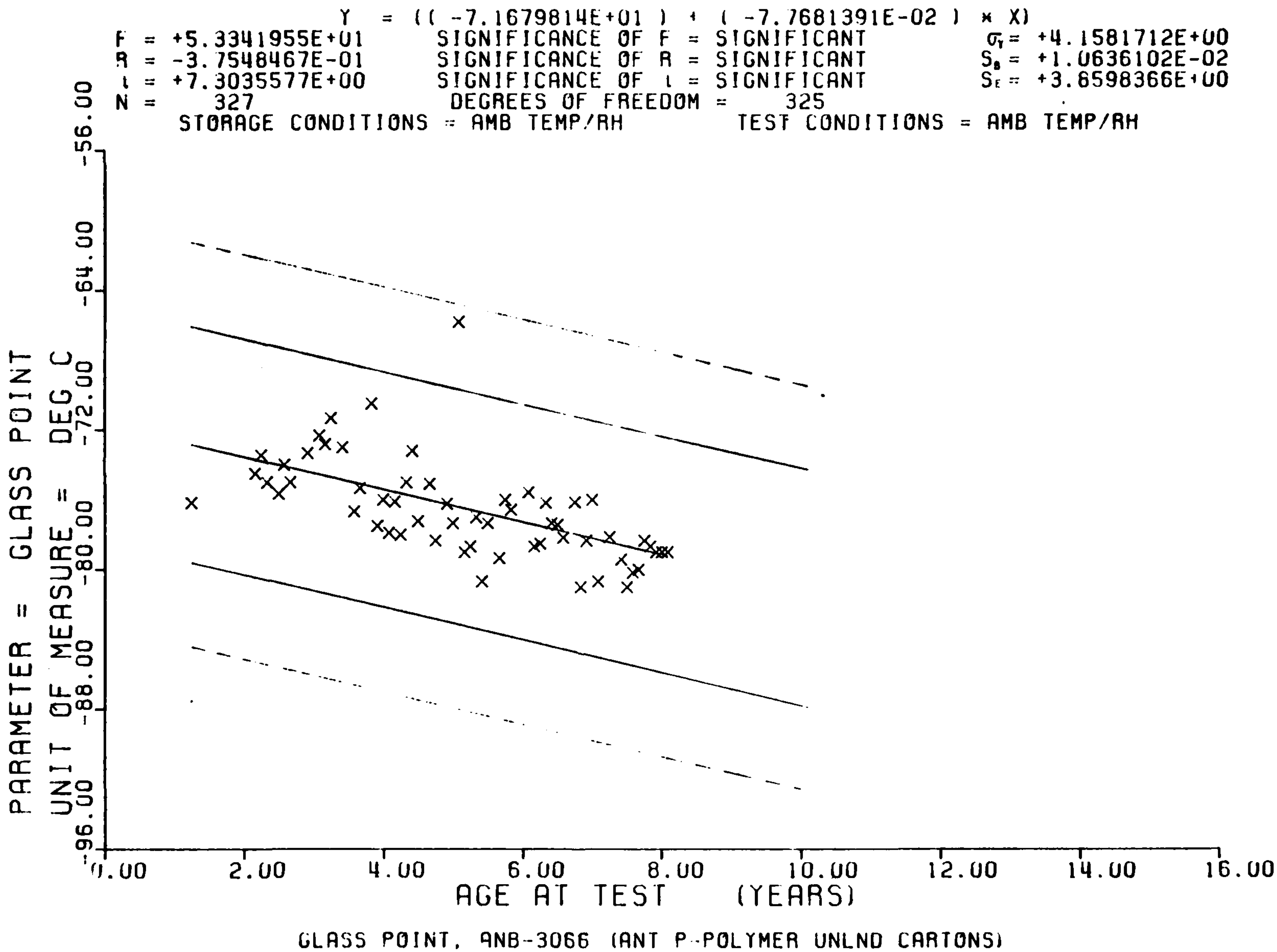

Y = ((-7.1679814E+01) + (-7.7681391E-02) × X)
F = +5.3341955E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_T = +4.1581712E+00
R = -3.7548467E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.0636102E-02
t = +7.3035577E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +3.6598366E+00
N = 327 DEGREES OF FREEDOM = 325
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = GLASS POINT
UNIT OF MEASURE = DEG C
-56.00
-64.00
-72.00
-80.00
-88.00
-96.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
GLASS POINT, ANB-3066 (ANT P-POLYMER UNLND CARTONS)

Figure 7-7

Y = ((+4.2197215E-05) + (+2.2207773E-07) * X)

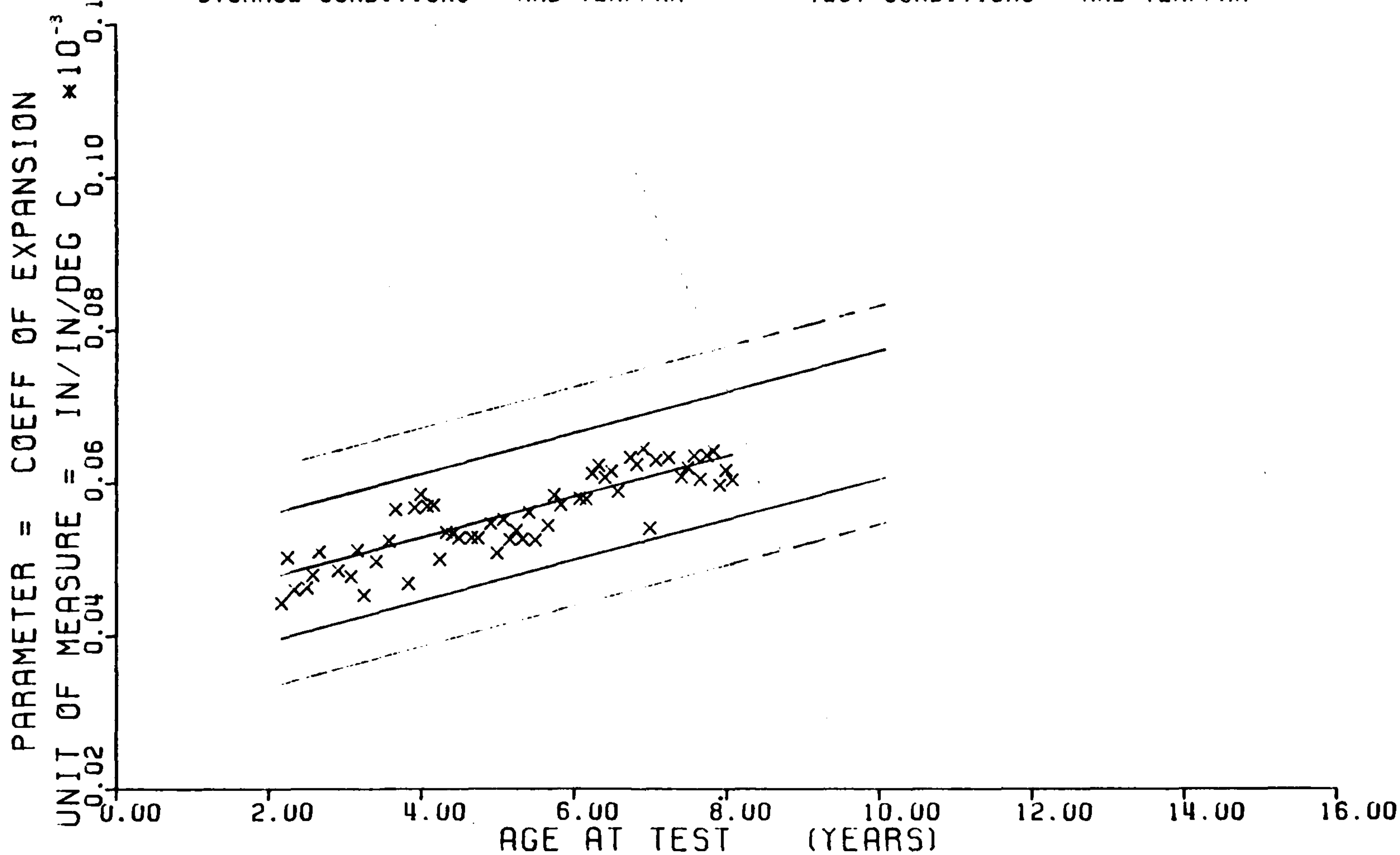
F = +2.5884936E+02 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +6.4086020E-06

R = +6.6929292E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.3803253E-08

t = +1.6088796E+01 SIGNIFICANCE OF t = SIGNIFICANT S_E = +4.7690400E-06

N = 321 DEGREES OF FREEDOM = 319

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



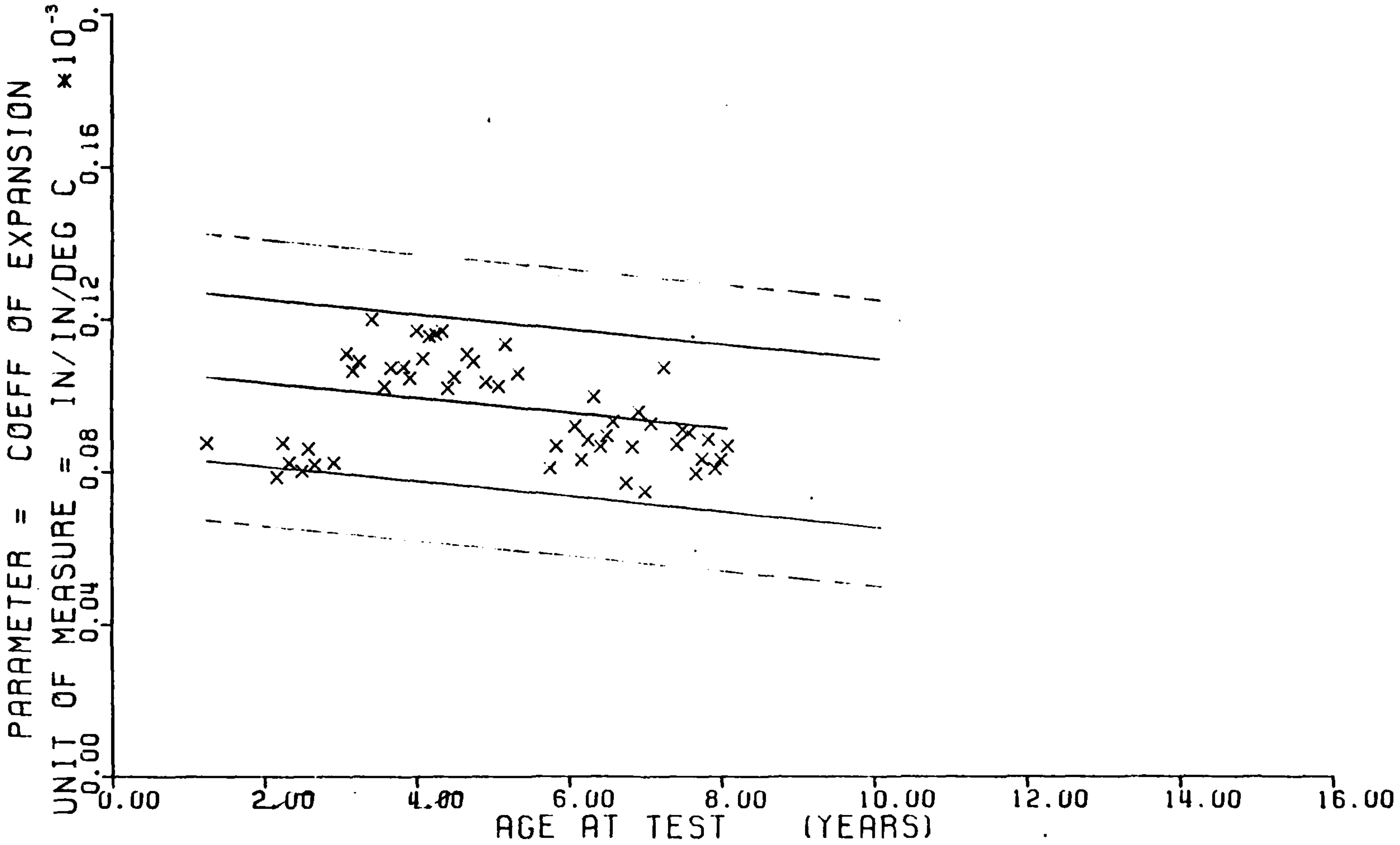
TCLE BELOW GLASS POINT, ANB-3066 (ANT P-POLYMER UNLND CARTONS)

Figure 7-8

Y = ((+1.0727346E-04) + (-1.0635393E-07) * X)

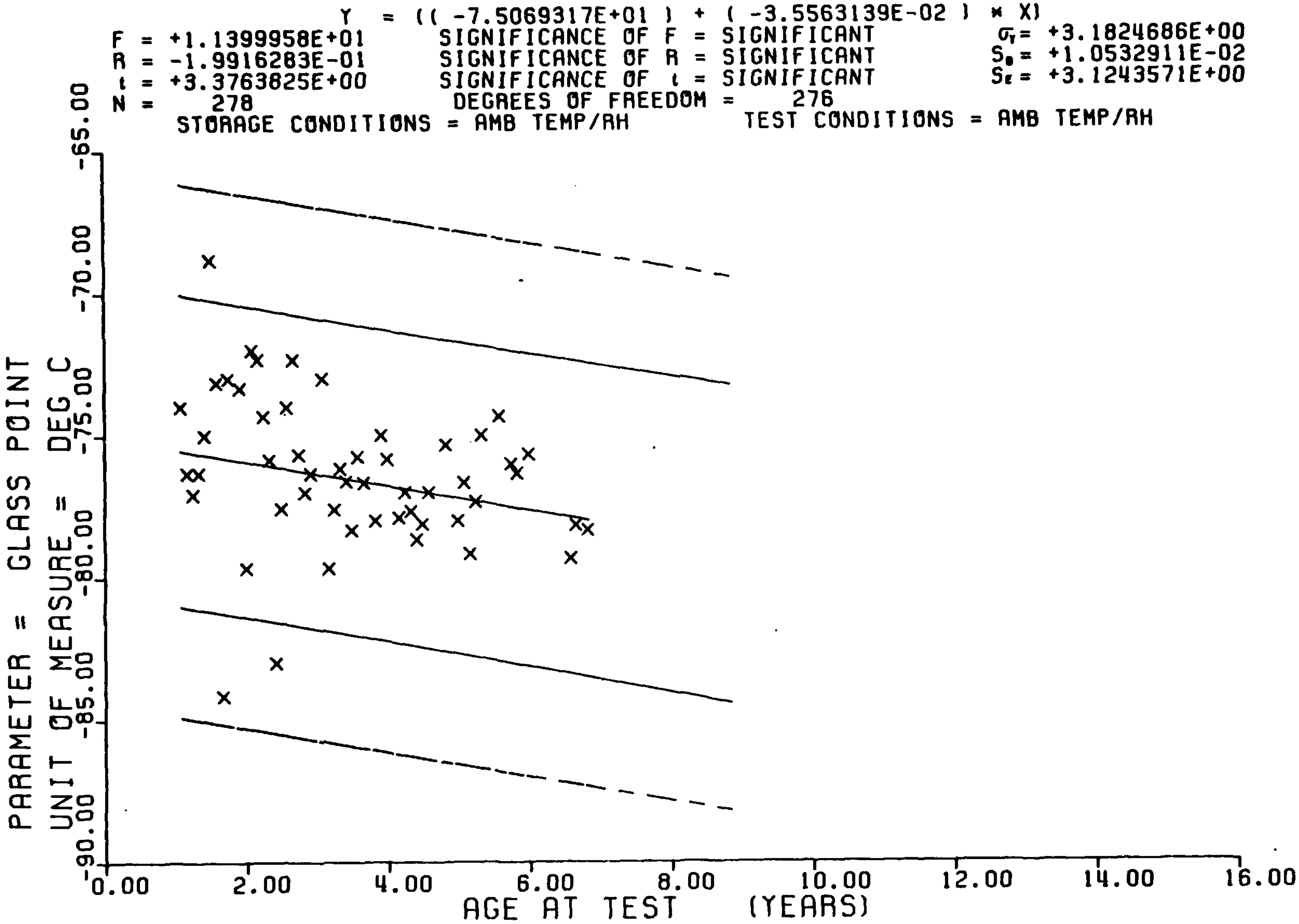
F = +2.3269920E+01   SIGNIFICANCE OF F = SIGNIFICANT σ_T = +1.2947333E-05
R = -2.6913019E-01   SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.4485428E-08
t = +4.8238906E+00   SIGNIFICANCE OF t = SIGNIFICANT S_E = +1.2490530E-05
N = 300   DEGREES OF FREEDOM = 298

STORAGE CONDITIONS = AMB TEMP/RH   TEST CONDITIONS = AMB TEMP/RH



TCLE ABOVE GLASS POINT, ANB-3066 (ANT P-POLYMER UNLND CARTONS)

Figure 7-9



GLASS POINT, ANB-3066 (ANT P-POLYMER LINED CARTONS)

Figure 7-10

Y = ((+5.6018817E-05) + (+5.1127121E-08) × X)

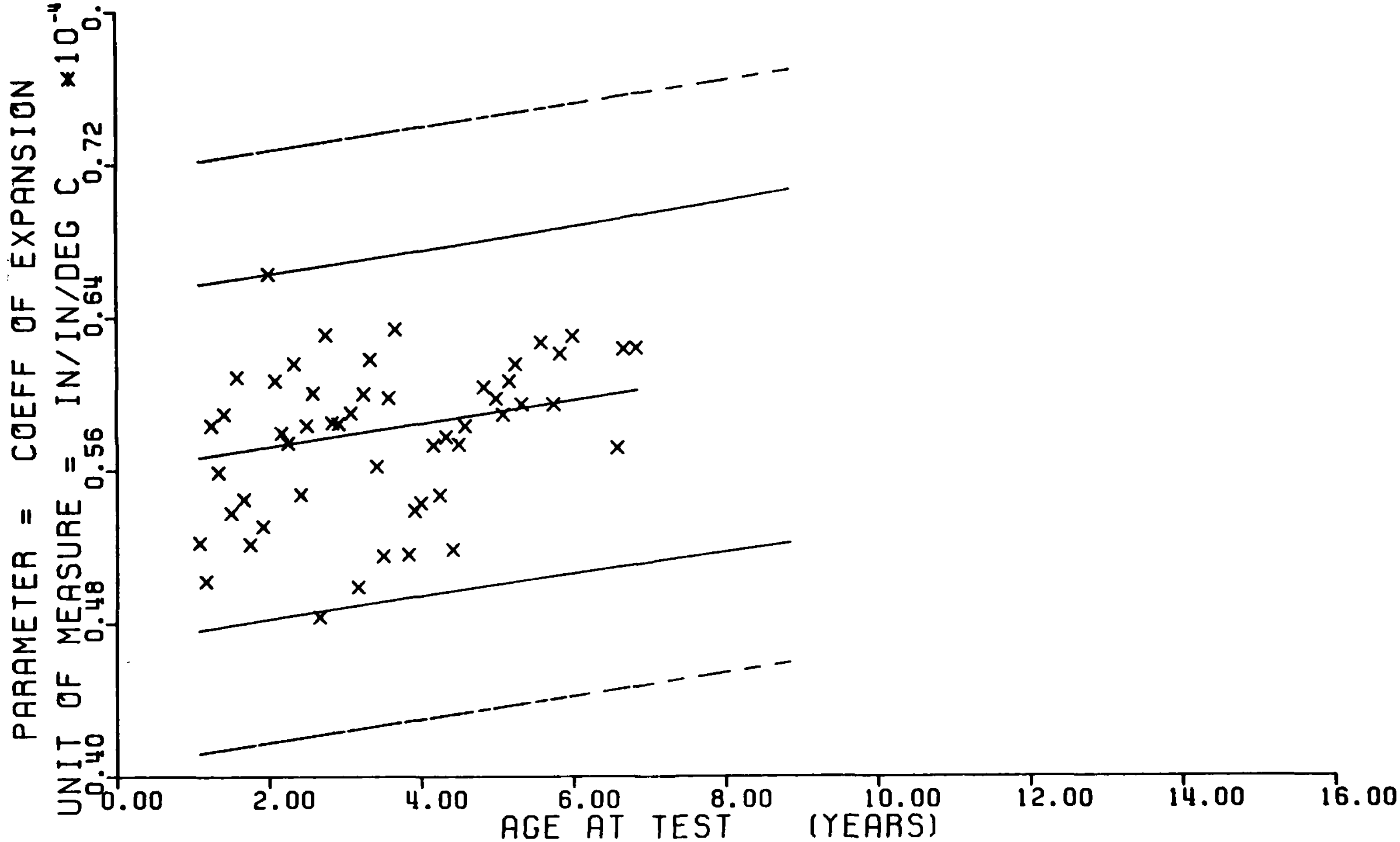
F = +8.6332018E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +5.2321538E-06

R = +1.7415789E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +1.7400646E-08

ι = +2.9382310E+00 SIGNIFICANCE OF ι = SIGNIFICANT S_E = +5.1615199E-06

N = 278 DEGREES OF FREEDOM = 276

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TCLE BELOW GLASS POINT, ANB-3066 (ANT P-POLYMER LINED CARTONS)

Figure 7-11

Y = ((+1.0311296E-04) + (-9.7065835E-08) * X)

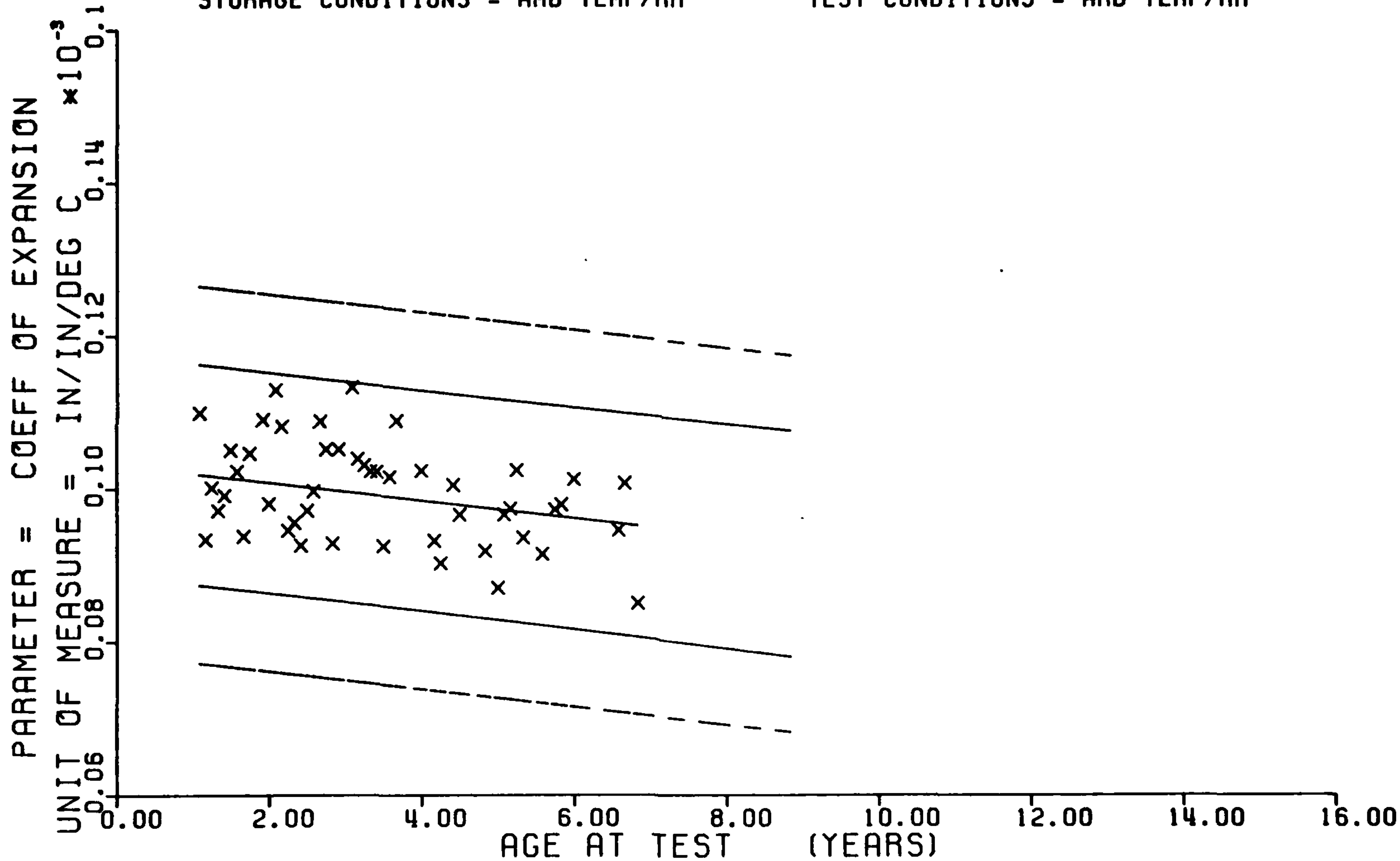
F = +1.1886196E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +8.3807414E-06

R = -2.1223309E-01 SIGNIFICANCE OF R = SIGNIFICANT S_B = +2.8154313E-08

t = +3.4476363E+00 SIGNIFICANCE OF t = SIGNIFICANT S_E = +8.2060539E-06

N = 254 DEGREES OF FREEDOM = 252

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TCLE ABOVE GLASS POINT, ANB-3066 (ANT P-POLYMER LINED CARTONS)

Figure 7-12

SECTION VIII

CASE LINER BONDS

Cartons of propellant were lined with SD-851-2 liner/v45 rubber simulating motor conditions. In the preparation of the cartons, liner sometimes penetrated the propellant to a depth of 0.5 inches. Irregularities are most apparent on outer surfaces. Corners may be particularly affected by curvature of the insulation.

Liner color varies from a pale buff to deep buff or a deep pink which apparently develops from moisture plus anti-oxidant. In general, the pink liner tends to be sticky and strings out in tensile testing. Shear strength may be negligible.

Aerojet did a study of 44 manufactuing variables to determine those which had a significant effect on liner bond strength. According to their report (MVS-1, June 76) several factors had a statistically significant effect on bond strength. Initial high bond strength and low insulation moisture content usually mean a longer time to degradation of the liner bond.

OO-ALC has made an extensive statistical study of the constant load tensile and shear tests. Regressions for these data as well as other parameters will be published in a supplement to this report.

SECTION IX

TEAR ENERGY

Tear energy specimens are microtomed to a thickness of 0.1 in (.254 cm) from a block of propellant 3" x 1 1/8" x 1 1/2" (7.62 cm x 2.8 cm x 3.8 cm). The microtomed specimen is bonded to wood and a 1 inch (2.54 cm) slit is cut lengthwise in the center of the specimen. Specimens are tested at four temperatures (40°, 77°, 120° and 160°F) and three rates (0.01 in/min, 0.1 in/min and 1.0 in/min) on the Instron.

Time to tear is measured at crack initiation. Cohesive tear energy is calculated from the critical stress and strain at that same time. As with other tests involving increasing rates, time to tear decreases with an increasing rate. Cohesive energy usually decreases with increasing temperature.

Time to tear is a more consistent parameter than cohesive tear energy. Lined cartons of "P" Polymer do not show a trend at any temperature and unlined cartons of ANT P shows a significant increase at all temperatures. The dimensions of the specimen also enter into the calculation.

TABLE 9-1

TEAR ENERGY

Significance of Regression Slopes

System	Temp °F	Cohesive Energy	Time to Tear
ANB G Unlined	40	NS	NS
	77	Sig inc	Sig inc
	120	Sig inc	Sig inc
	160	Sig inc	Sig inc
ANB G Lined	40	NS	NS
	77	Sig inc	Sig inc
	120	NS	NS
	160	NS	Sig inc
ANB P Unlined	70	Sig inc	NS
	77	Sig inc	Sig inc
	120	Sig inc	Sig inc
	160	NS	NS
ANB P Lined	40	NS	NS
	77	NS	NS
	120	NS	NS
	160	Sig dec	NS
ANT P Unlined	40	Sig inc	Sig inc
	77	Sig inc	Sig inc
	120	NS	Sig inc
	160	NS	Sig Inc
ANT P Lined	40	Sig inc	NS
	77	NS	NS
	120	NS	NS
	160	NS	NS

NS = Not significantly different from zero slope
Sig inc = Positive slope
Sig dec = Negative slope

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER MAKPH Report Nr 450(80)	2. GOVT ACCESSION NO. AD-A102979	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Propellant Surveillance Report ANB-3Ø66 Propellant		5. TYPE OF REPORT & PERIOD COVERED Test Results / Semi Annual 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) ELIZABETH M./DALABA		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Propellant Analysis Laboratory Directorate of Maintenance OO-ALC Hill AFB, UT 84056		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Airmunitions Management Division Directorate of Materiel Management OO-ALC Hill AFB, UT 84056		12. REPORT DATE December 1980 13. NUMBER OF PAGES 121
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Solid Propellant
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report contains test results from LGM-30 F & G, Stage II and Stage III Propellant. Data are shown in linear regression plots.

The differences between polymers used in the propellant are shown in the composite plots for very low rate tensile, high rate tensile and stress relaxation data and is most evident in gradient stress relaxation modulus.

Case liner bonds continue to show significant degradation although the rate of change has slowed.

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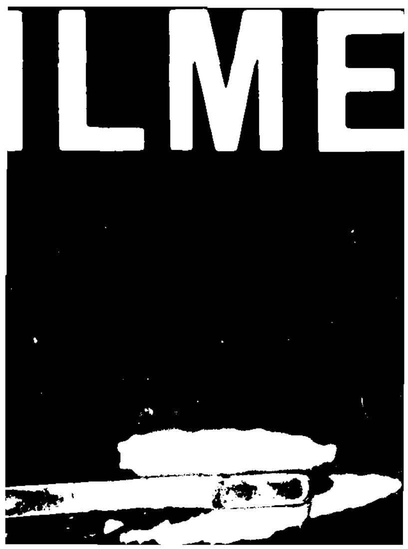
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